Waterloo Sanitary Master Plan

VOLUME 1

Prepared for:
City of Waterloo

Prepared by:
Stantec Consulting Ltd.

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Sign-off Sheet

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Executive Summary

The City of Waterloo has initiated an update to the previous 2002 City Wide Sanitary Sewer System Update (2002 Master Plan). The purpose of the 2014 Master Plan Update is to account for increases in population and employment growth projections up to a planning horizon of 2031, including provision of municipal servicing to existing privately-serviced properties. This Master Plan Final Report includes an outline of priority and strategic projects which will allow the system to continue to operate efficiently and effectively. Recommendations include the implementation of identified best management practices for Inflow/Infiltration (I/I) reduction and rehabilitation measures, and optimized staging of the sanitary capital program.

The collection system provides sanitary servicing for the majority of the residents in Waterloo and also receives flows from the City of Kitchener (Bridgeport and Falconridge Sewage Pump Stations), the Township of Woolwich (Stockyards Industrial/Commercial Area and King 86 Power Centre Area), and the Township of Wilmot (Fire Training Centre). The City owns approximately 420 km of sanitary sewers and six (6) sewage pumping stations. Sewage is conveyed to the Waterloo Wastewater Treatment Plant (WWTP) for treatment prior to discharge to the Grand River.

The Master Plan recommendations consist of a series of individual projects grouped into Priority Projects and Strategic Projects which collectively constitute the preferred Master Plan Servicing Scheme. The Priority Projects are recommended to be completed within the next five (5) year cycle, and Strategic Projects are grouped into five (5) year increments.

- Priority Projects (2016 to 2019)
- Strategic Projects (2020 to 2024)
- Strategic Projects (2025 to 2029)

A review of the 2015 Approved 10 year Capital Budget has been completed to identify opportunities to defer or delete previously identified projects based on the findings of the 2014 Master Plan Update. Five projects are recommended to be deleted from the Capital Budget given previously assumed capacity constraints were not confirmed to exist in the 2014 Master Plan within these areas. Additional flow monitoring is recommended to confirm that these upgrades are not required.

The recommendations and opinion of probable cost also include the following components:

- Existing budget items, with the exception of the deleted projects;

- Capital Upgrades at three locations where capacity constraints have been identified within the sanitary sewer network. These constraint locations include: Maple Hill Trunk, Downstream of Frobisher SPS, and the Lower Forwell Trunk;
- An ongoing flow monitoring program to aid in the reduction of extraneous flow, and monitor system capacity;
- A Rehabilitation and Optimization Plan to extend the life of existing infrastructure; and
- A provision for municipal servicing to existing privately-serviced properties.

A full list of these recommended capital projects and the associated opinion of probable cost is summarized in Table E-1. The opinion of probable cost for each of the capital upgrades includes a Capital Cost Contingency and a Project Delivery Allowance. These estimates were prepared based on preliminary sizing of the required system components and consideration for the topography of proposed development areas. Cost estimates for all existing projects were obtained from the City of Waterloo 2015 Approved Capital Budget.

Table E-1: Preliminary Plan for Implementation and Staging

Project Description	EA and Study Requirements	Priority Projects (2016 to 2019)	Strategic Projects (2020 to 2024)	Strategic Projects (2025 to 2029)
Projects Currently Carried in the 2015 Capital Budget				
Capital Upgrades Carried in Recommendations	Schedule 'B'	$10,302,000	$5,805,000	$ -
Capital Upgrades Not Carried in Recommendations	Schedule 'B'	$1,676,000	$621,000	$ -
2014 MP Update Projects				
Municipal Servicing	Various	$132,000	$2,805,000	$9,644,000
Capital Upgrades	Schedule 'A'	$36,000	$164,000	$ -
Flow Monitoring Program	N/A	$194,000	$160,000	$160,000
Optimization and Rehabilitation	N/A	$1,641,000	$1,014,000	$1,843,000
Monitoring of Projects Removed from Capital Budget	N/A	$29,000	$ -	$ -
Total Costs per Planning Period		**$12,334,000**	**$ 10,626,000**	**$11,647,000**

Abbreviations

SPS	Sewage Pumping Station
I/I	Inflow/Infiltration
WWTP	Wastewater Treatment Plant
DWF	Dry Weather Flow
WWF	Wet Weather Flow
PCC	Public Consultation Centre
GIS	Geographic Information System
MCEA	Municipal Class Environmental Assessment
CEAA	Canadian Environmental Assessment Act
MP	Master Plan
ESPA	Endangered Species Protection Area
CNR	Canadian National Railway Company
CAIA	Core Area Infrastructure Assessment
IDF	Intensity Duration Frequency
LID	Low Impact Development
BMP	Best Management Practice
GRCA	Grand River Conservation Area
MOECC	Ministry of Environment and Climate Change
KW	Kitchener Waterloo
ICI	Industrial, Commercial & Institutional Land Uses
LRT	Light Rail Transit
ADSF	Average Dry Weather Sewage Flow
SCADA	Supervisory Control and Data Acquisition
CofA	Certificate of Approval
RTK	RTK Unit Hydrograph Method
DGSSMS	Design Guidelines and Supplemental Specifications for Municipal Services
WRESTRC	Waterloo Region's Emergency Training & Research Complex
ESA	Environmentally Sensitive Area
CCTV	Closed Circuit Television
CAIA	Core Area Infrastructure Assessment
I/I	Inflow/Infiltration
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

The City of Waterloo (City) has a population of approximately 132,300, including post-secondary students, and has a sanitary collection system that services a land area of approximately 64 square kilometers (km^2). The collection system provides sanitary servicing for the majority of the residents in Waterloo and also receives flows from the City of Kitchener (Bridgeport and Falconridge Sewage Pump Stations), the Township of Woolwich (Stockyards Industrial/ Commercial Area and King 86 Power Centre Area), and the Township of Wilmot (Fire Training Centre). The City owns approximately 420 km of sanitary sewers and six (6) sewage pumping stations. Sewage is conveyed to the Waterloo Wastewater Treatment Plant (WWTP) for treatment prior to discharge to the Grand River.

The City retained Stantec Consulting Ltd. (Stantec) to complete the 2014 Waterloo Sanitary Sewer System Master Plan Update (Master Plan), which provides an update to the 2002 City Wide Sanitary Sewer System Update (2002 Master Plan). The purpose of the 2014 Master Plan Update is to account for increases in population and employment growth projections up to a planning horizon of 2031, including provision of municipal servicing to existing privately-serviced properties. The result of this Master Plan Final Report includes an outline of priority and strategic projects which will allow the system to continue to operate efficiently and effectively.

The Master Plan Update project was planned and implemented in accordance with the Municipal Class Environmental Assessment (Class EA) process for Master Plans (Municipal Engineers Association, June 2000, as amended in 2007 and 2011). The project was organized to consist of a City Project Team and Consultant Project Team. The Master Plan Update was completed by accomplishing seven (7) major tasks including:

- Task 1: GIS Sanitary Quality Control and Field Verification
- Task 2: Hydraulic Needs Assessment
- Task 3: Hydraulic Model Benefit/Cost Analysis
- Task 4: Hydraulic Model Development
- Task 5: Flow Monitoring and Inflow/Infiltration
- Task 6: Public Consultation
- Task 7: Master Plan

Outcomes of Tasks 1 through 5 were used to develop a hydraulic model and the outcomes of Task 7 utilized the newly developed hydraulic model to identify constraints and develop alternatives to accommodate future growth. As part of the Master Plan, alternatives were evaluated to determine the preferred servicing strategies and provide recommendations for

implementation. The purpose of the Final Report for the Master Plan is to summarize the master planning process, the outcome of the above tasks, and outline recommended priority and strategic projects. This report is organized into nine (9) sections:

- Section 1.0 provides an introduction to the project, the structure of the Report, and project objectives.
- Section 2.0 provides project background including impacts of climate change, the 2002 Master Plan, an overview of the City sanitary system, drivers for the project, and relevant studies.
- Section 3.0 includes the Master Plan Update process and methodology, and an overview of the public and agency consultation which occurred throughout the Master Plan.
- Section 4.0 provides a Study Area Inventory including population and growth projections, inter-municipal sewage flows, and a summary of natural, social and economic features.
- Section 5.0 provides an overview of the model development process.
- Section 6.0 provides an overview of the capacity analysis and needs assessment for greenfield development areas, infill and intensification development, municipal servicing for existing private services, and capacity constraints related to planned growth. This section also includes a summary of the I/I program recommendations and optimization and rehabilitation program recommendations.
- Section 7.0 presents a summary of recommendations for servicing strategies including proposed priority and strategic projects, including recommendations of the staging and implementation of projects.
- Section 8.0 presents the opinion of probable cost for the proposed priority and strategic projects.
- Section 9.0 provides report references.

1.1 PROBLEM OPPORTUNITY STATEMENT AND OBJECTIVES FOR THE MASTER PLAN UPDATE

The 2002 City-wide Sanitary Servicing Strategy Master Plan Update provided recommendations to address anticipated growth to a planning horizon of 2016. This 2014 Waterloo Sanitary Sewer System Master Plan Update was initiated to address anticipated growth to a planning horizon of 2031. Priority and strategic projects were evaluated to efficiently and effectively continue to operate the system, implement best management practices (including Infiltration/Inflow (I/I) monitoring and mitigation approaches), and optimize staging of the sanitary capital program. The Master Plan serves as an update to the 2002 Master Plan, which identified priority (2002 to 2006) and strategic (2007 to 2016) projects.

The objectives of the Master Plan were to:

- Support demand and capacity decisions for the City by developing a sanitary hydraulic model for the purposes of updating the 2002 Master Plan.
- Complete the Master Plan in accordance with Municipal Engineers' Association document entitled "Municipal Class Environmental Assessment" October 2000, as amended in 2007 and 2011.
- Identify priority and strategic projects including expansion and upgrades to existing infrastructure and construction of new infrastructure necessary to meet growing demands on the system.
- Provide a capital forecast up to 2031, including opinions of probable cost.

1.2 MASTER PLANNING PROCESS

Master Plans are part of the Municipal Class Environmental Planning Process (Municipal Engineers Association, June 2000, as amended in 2007 and 2011) and are intended to provide long range plans that integrate infrastructure requirements for existing and future land use with environmental assessment planning principles. A Master Plan is an assessment of an infrastructure system or group of related projects, such as a municipal sanitary collection system, in order to outline a framework for planning subsequent projects and developments. Individual projects will result from the Master Plan, however, the master planning process allows the need and justification for individual projects and the associated broader context to be better defined and help guide environmental planning at the project specific level.

Long range infrastructure planning enables the City to comprehensively identify needs and establish broader infrastructure options. The combined impact of alternatives is also better understood which may lead to more and better solutions. The opportunity to integrate land use planning enables the City to look at the full impact of decisions from a variety of perspectives. The scope of Master Plans is broad and usually includes an analysis of the system in order to outline a framework for future works and developments. They are not typically undertaken to address a site-specific problem. Typically, Master Plans recommend a set of works which are distributed geographically throughout the study area and which are to be implemented over an extended period of time.

Key features of a Master Plan include:

- Incorporating key aspects of successful environmental assessment planning, which includes:
    - Consultation, reasonable ranges of alternatives, consideration of effects on all aspects of the environment, systemic evaluation, clear documentation, traceable decision-making.

- Addressing at least the first two phases of the Municipal Class EA (see Figure 1-1).
- Providing long-term planning framework for the Municipality by:
    - Integration of other planning initiatives.
    - Holistic, system-wide approach.
    - Consideration of spatial and temporal distribution of changes and projects.
- Recommending a strategy which can be implemented through separate projects:
    - Provides a description of these projects which will be carried out by the appropriate EA process (i.e. Schedule A, A+, B, C) and be used to support and provide basis for future Schedule B and C projects.

Public and agency consultation are crucial, especially at the project initiation so the scope and purpose of the study is understood and at the selection of the preferred set of alternatives. The Master Planning process should address the first two (2) phases in the Planning and Design Process of the Class EA. Refer to Figure 1-1 for the major stages of the Master Plan.

As outlined in the MCEA, 2011, the Master Plan should be reviewed every five years to determine the need for a detailed update. Potential changes which may trigger a Master Plan update include:

- Major changes in environmental policy and regulations; refer to CEAA 2012.
- Major changes in planning policy.
- Major changes in original assumptions (i.e. change in sanitary flow rates, design storms, etc.).
- Significant new environmental effects.
- Major changes in proposed timing and/or scope of projects recommended within the Master Plan.

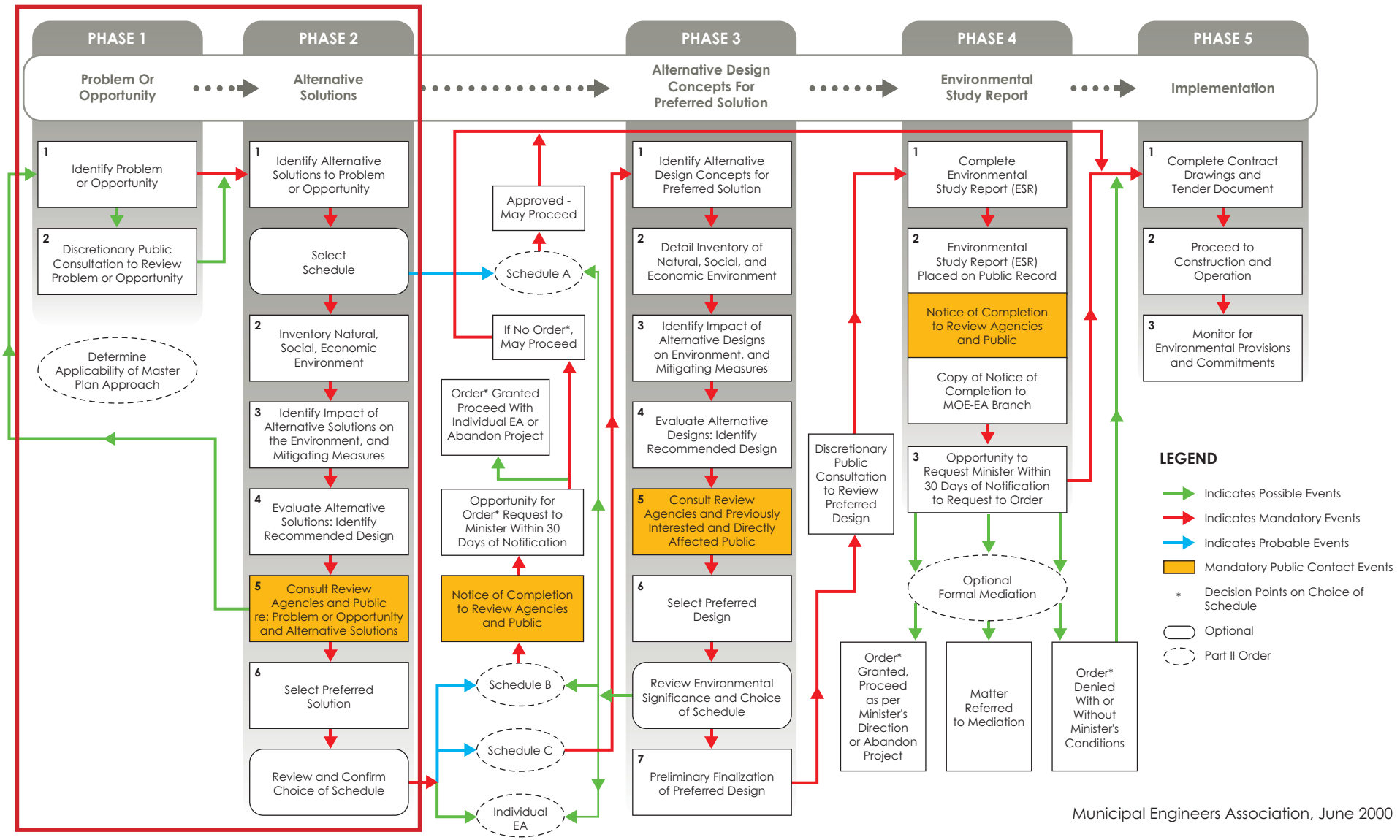
PHASE 1
PHASE 2
PHASE 3
PHASE 4
PHASE 5
Problem Or Opportunity
Alternative Solutions
Alternative Design Concepts For Preferred Solution
Environmental Study Report
Implementation
1 Identify Problem or Opportunity
2 Discretionary Public Consultation to Review Problem or Opportunity
Determine Applicability of Master Plan Approach
1 Identify Alternative Solutions to Problem or Opportunity
Select Schedule
2 Inventory Natural, Social, Economic Environment
3 Identify Impact of Alternative Solutions on the Environment, and Mitigating Measures
4 Evaluate Alternative Solutions: Identify Recommended Design
5 Consult Review Agencies and Public re: Problem or Opportunity and Alternative Solutions
6 Select Preferred Solution
Review and Confirm Choice of Schedule
Approved - May Proceed
Schedule A
If No Order*, May Proceed
Order* Granted Proceed With Individual EA or Abandon Project
Opportunity for Order* Request to Minister Within 30 Days of Notification
Notice of Completion to Review Agencies and Public
Schedule B
Schedule C
Individual EA
1 Identify Alternative Design Concepts for Preferred Solution
2 Detail Inventory of Natural, Social, and Economic Environment
3 Identify Impact of Alternative Designs on Environment, and Mitigating Measures
4 Evaluate Alternative Designs: Identify Recommended Design
5 Consult Review Agencies and Previously Interested and Directly Affected Public
6 Select Preferred Design
Review Environmental Significance and Choice of Schedule
7 Preliminary Finalization of Preferred Design
Discretionary Public Consultation to Review Preferred Design
1 Complete Environmental Study Report (ESR)
2 Environmental Study Report (ESR) Placed on Public Record
Notice of Completion to Review Agencies and Public
Copy of Notice of Completion to MOE-EA Branch
3 Opportunity to Request Minister Within 30 Days of Notification to Request to Order
Optional Formal Mediation
Order* Granted, Proceed as per Minister's Direction or Abandon Project
Matter Referred to Mediation
Order* Denied With or Without Minister's Conditions
1 Complete Contract Drawings and Tender Document
2 Proceed to Construction and Operation
3 Monitor for Environmental Provisions and Commitments
LEGEND
Indicates Possible Events
Indicates Mandatory Events
Indicates Probable Events
Mandatory Public Contact Events
* Decision Points on Choice of Schedule
Optional
Part II Order
Municipal Engineers Association, June 2000

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FIGURE 1-1
Municipal Class EA Process for Master Planning
City of Waterloo / Waterloo Sanitary Master Plan Update

2.0 PROJECT BACKGROUND

2.1 OVERVIEW OF THE SANITARY COLLECTION SYSTEM

The sanitary collection system consists of approximately 420 km of sanitary sewers (local sewers, trunk sewers, and forcemains) and six (6) sewage pump stations (SPS) collectively book-valued at $124M (City of Waterloo, 2011). Sewage collected from the sanitary system is conveyed to the WWTP, which provides treatment for a 5 year average projected flow of 46,693 m^3/day, according to the *Water and Wastewater Monitoring Report* (Region of Waterloo, 2013). Within the City, there are areas not presently connected to the municipal sanitary collection system including Country Squire Estates, residential properties in Colonial Estates and other outlying areas which are on private septic systems.

Additional flows are received from the outside of the City boundaries. These sources include portions of the Township of Woolwich and two (2) sewage pumping stations located in the City of Kitchener.

Figure 2-1 shows the City sanitary collection system, SPS and forcemains, contributors for external flows, and areas currently on private/septic services. Additional details regarding the collection system are provided in Tech Memo 1 (refer to Volume 2, Appendix E).

2.2 DRIVERS FOR THE MASTER PLAN

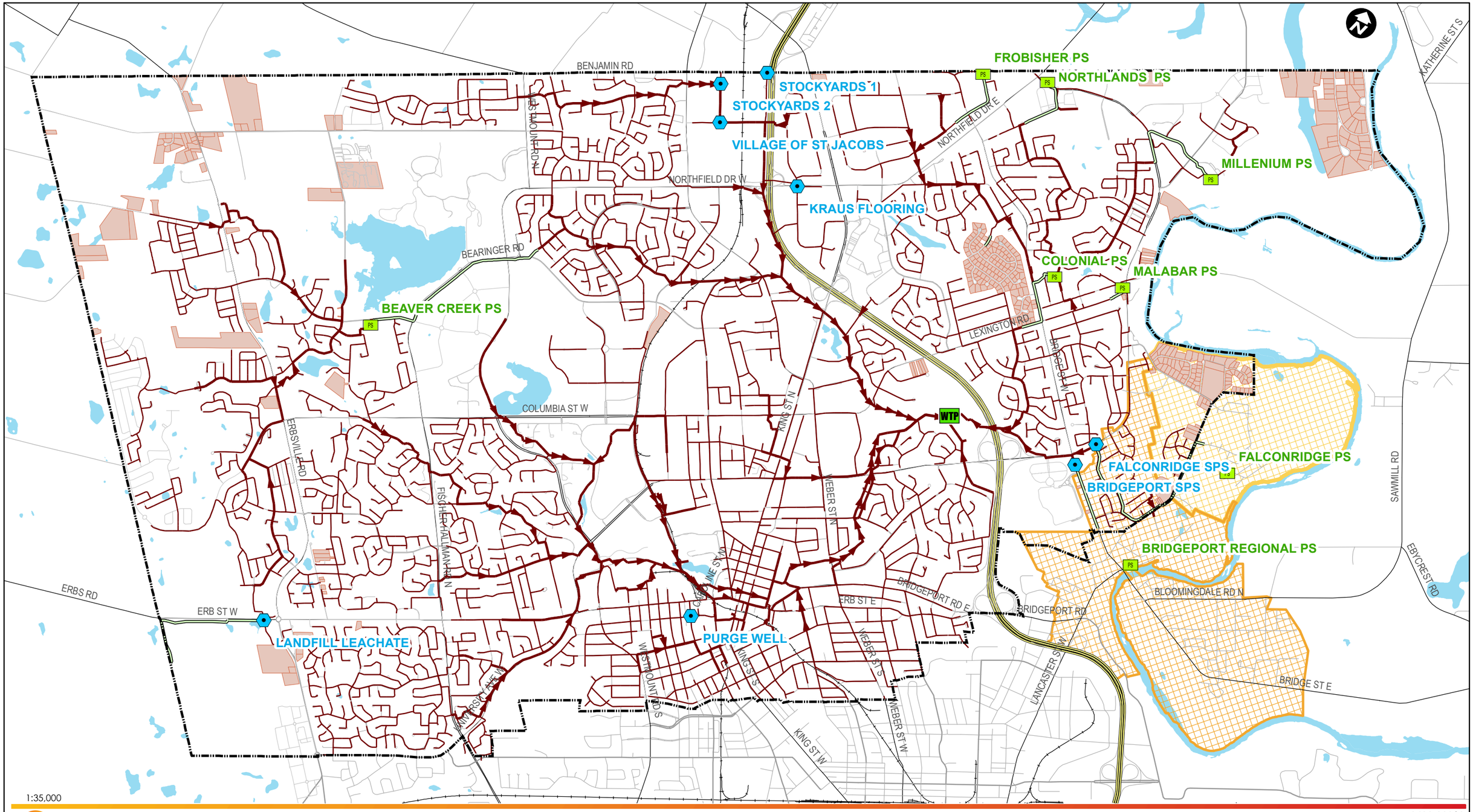
The key factors driving the Master Plan include:

1. Need to identify up-to-date recommendations for priority and strategic projects to accommodate proposed growth up to the 2031 planning horizon.

2. Update sanitary flow projections based on up-to-date population projections for the City of Waterloo and contributing areas.

3. Update the understanding of I/I in the system based on recently-collected flow monitoring information, system upgrades completed since the 2002 Master Plan, and the definition of level of service in light of climate change considerations.

4. Developing a new sanitary hydraulic modeling tool for long-term use in assisting decision support and implementation planning.



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Legend

- PS — Existing Pump Station
- Forcemain
- WTP — Wastewater Treatment Plant

Sanitary Sewers

- Local Sewer
- Trunk Sewer

- External Contributions and Large Users
- Unserviced Property

Kitchener Drainage Areas

- Bridgeport Pump Station
- Falconridge Pump Station

1611-11191

Figure No. FIGURE 2-1

Title **SANITARY DRAINAGE NETWORK**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE

2.3 RELEVANT STUDIES

Several key studies undertaken since the 2002 Master Plan and alongside this Master Plan have been incorporated into this study. A number of the infrastructure projects recommended in the 2002 Master Plan have also been constructed or are in progress. The key studies and status of recommended infrastructure projects are outlined herein. Building on the recommendations of the 2002 Master Plan, the drivers and contributing factors for the update are described in more detail in the following subsections. Full references to each document are provided in Section 9.0.

2.3.1 2002 City-Wide Sanitary Sewer Study Master Plan Update (2002 Master Plan)

The 2002 Master Plan was completed as an update to the 1989 Trunk Sanitary Sewer Study which provided recommendations for sanitary servicing upgrades to accommodate new development up to the year 2031. The 2002 Master Plan identified and reviewed sewage servicing alternatives necessary to meet the servicing needs at the time of the study and future growth up to the year 2016, considering updated population projections, policy changes, and the status of projects identified in 1989.

The 2002 Master Plan identified both Priority and Strategic Projects to meet current and future servicing needs. Priority Projects were to be completed from 2002 to 2006 and were considered critical to system operation and/or allowing the timely expansion of the system to accommodate development. Strategic Projects were to be completed from 2007 to 2016 and were considered required to meet approved growth projections and commitments to the planning year of 2016. Table 2-1 provides a summary of the 2002 Master Plan recommended projects and the current status.

Table 2-1: Current Status of 2002 Master Plan Recommended Projects

Project in 2002 MP	Status
Ref. #01 - Beaver Creek SPS Upgrades and Forcemain	Included in 2015 Capital Budget (See 2002 MP Ref. #22)
Ref. #02 - Colonial SPS - two pump upgrades	Completed
Ref. #03 - Cedar Trunk 1 (south) Extension - Paris Boulevard to Erb Street and west along Erb Street West, 375 mm dia.	Completed
Ref. #04 - Maple Hill Trunk Replacement	Included in 2015 Capital Budget
Ref. #05 - Cedar Trunk 1 (south) Rheinland to Clair Hills Limit Stage 5, Gravity Sewer, 300 mm dia.	Completed
Ref. #06 - Cedar Trunk 3 (North) Cedar Bend to ESPA Gravity Sewer, 525 mm dia.	Completed
Ref. #07 - CNR Trunk Replacement Columbia Street to Silver Lake Gravity Sewer, 525 mm dia.	Completed

Project in 2002 MP	Status
Ref. #08 - Cedar Trunk 3 (North) Extension ESPA to Erbsville Road, Gravity Sewer, 525 mm dia.	Completed
Ref. #09 - Beaver Creek Road Trunk (North) Extension - Beaver Creek Road Gravity Sewer #1, 375 mm dia.	Completed
Ref. #10 - Cedar Trunk 3 (North) Extension - Wideman Road Gravity Sewer #1, 300 mm dia.	Completed
Ref. #11 - Eastbridge Trunk Extension (Rural East Lands) - Gravity Sewer, 300 mm dia.	Completed
Ref. #12 - Cedar Trunk 1 (South) Extension	Included in 2015 Capital Budget
Ref. #13 - Cedar Trunk 1 (South) Extension - Clair Hills - Limit Stage 5 to HEPC Gravity Sewer, 300 mm dia.	Completed
Ref. #14 - Malabar SPS Pump Upgrades	Completed
Ref. #15 - Cedar Trunk 1 (South) Extension - HEPC to Wilmot Line Gravity Sewer, 300 mm dia.	Completed
Ref. #16 - Maple Hill Trunk Replacement - University Avenue south of Erb Street, Gravity Sewer, 450 mm dia.	Completed
Ref. #17 - Lexington Trunk Extension - Gravity Sewer, 200 and 250 mm dia.	EA Currently Underway
Ref. #18 - Cedar Trunk 2 (West) Extension - Columbia Forest Court to Wilmot Line, Gravity Sewer, 375 mm dia.	Completed
Ref. #19 - Forwell Trunk - Cap and Protect at Laurel Creek crossing Gravity Sewer, 825 mm dia.	Completed
Ref. #20 - Cedar Trunk 3 (North) Extension - Wideman Road Gravity Sewer #2, 300 mm dia.	Servicing Strategy Underway[1]
Ref. #21 - Keats Trunk Sewer Replacement	Not Yet Completed
Ref. #22 - Beaver Creek SPS, Twin Forcemain 500 mm dia.	Completed
Ref. #23 - Laurel Trunk Twinning - Marshall Street to WWTP Gravity Sewer, 1,200 mm dia.	Completed
Ref. #24 - Maple Hill Trunk Replacement	Included in 2015 Capital Budget
Ref. #25 - SPS #1 - 111 L/s Erbsville Road	Not Required. This area will be serviced by SPS #2 and SPS #3[1]
Ref. #26 - Laurel Trunk Relief Sewer - CNR Trunk to Peppler Street, Gravity Sewer, 750 mm dia.	Completed
Ref. #27 - Beaver Creek Road Trunk Extension	Servicing Strategy Underway[1]
Ref. #28 - Beaver Creek Road Trunk Extension	Servicing Strategy Underway[1]
Ref. #29 - Beaver Creek Road Trunk Extension	Servicing Strategy Underway[1]

Project in 2002 MP	Status
Ref. #30 - Laurel Trunk Relief Sewer - Father David Bauer Drive, Gravity Sewer, 600 mm dia.	Completed
Ref. #31 - Colonial SPS Upgrades and Forcemain	Completed
Ref. #32 - Beaver Creek Road Trunk Extension	Included in 2015 Capital Budget
Ref. #33 - Cedar Trunk 3 Extension - Conservation Drive west of SPS #1 Gravity Sewer 300 mm dia.	Servicing Strategy Underway[1]
Ref. #34 - (2012 to 2016) - Beaver Creek SPS #2 at 47 lps Conservation Drive.	Included in 2015 Capital Budget
Ref. #35 - SPS #4 - 27 L/s Wideman Road	Servicing Strategy Underway[1]
Ref. #36 - Beaver Creek Road Trunk Extension	Included in 2015 Capital Budget

Note 1: The Conservation Drive and Beaver Creek Road Upgrades and Extension of Municipal Services Class EA (Stantec, ongoing).

As seen outlined in Table 2-1, the majority of the priority projects identified in the 2002 Master Plan have been completed. The Strategic Projects outlined in the 2002 Master Plan continue to be implemented, with some completed, some with ongoing studies pending, and some with revised implementation dates. For example, the Beaver Creek Road and Conservation Drive Upgrades and Extension of Municipal Services Class EA is ongoing and will provide an update for servicing a significant area of development in the north-west area of the City (refer to Section 2.3.3 for additional details). The need and timing of implementation of the remaining recommendations from the 2002 Master Plan was re-evaluated in the Master Plan Update, these are discussed in Section 7.0.

2.3.2 Waterloo Core Area Infrastructure Assessment

The Core Area Infrastructure Assessment (CAIA) was completed in 2011, which looked at the potential impact of intensification associated with the uptown 'core area' on the water, sanitary, storm and transportation networks. A static, uncalibrated sanitary model (H2OMap Sewer) was created to assess the existing and future capacity constraints over multiple growth horizons, and provided high-level recommendations for sewer upgrades. The current status of each recommendation is summarized in Table 2-2.

Table 2-2: Status of Core Area Infrastructure Assessment Sanitary Recommended Upgrades

Description	CAIA, 2011	Comments
Ezra Avenue Sanitary Sewer Upsizing	Cluster 47 - Priority 1 and Priority 3 upgrades identified along Ezra.	Completed
Philip Street	Cluster 38 - Priority 1 upgrades and priority 2 upgrades identified.	Completed
Seagram Drive	Cluster 44: Priority 1 and Priority 2 upgrades identified.	Completed
Allen Street West	Cluster 89 - Priority 1 upgrades required.	Upgrades Not Completed
Columbia St W	Cluster 39 - Priority 1 and Priority 2 upgrades identified, and Priority 3 at the intersection of Wes Grahm way and Columbia.	Completed
Union St E	Cluster 75 - Priorities 1, 2, and 3 upgrades identified.	Upgrades Not Completed
Willis Way / Regina St S Sanitary Sewer Upsizing	Cluster 82 - Priority 1 upgrade along Regina at Willis Way, and Priority 2 along Willis Way and King St.	Upgrades Not Completed
University Ave East	Priority 1 and Priority 3 upgrades identified.	Completed
Bridgeport Rd E / Laurel St / Easement	Cluster 81 – Priority 1 upgrades identified along Bridgeport at Laurel, and along William. Priority 1 upgrades identified along easement at Erb and Laurel.	Upgrades Not Completed

2.3.3 Beaver Creek Road and Conservation Drive Upgrades and Extension of Municipal Services Class Environmental Assessment

The Beaver Creek Road and Conservation Drive Upgrades and Extension of Municipal Services Class EA is currently in progress to review and implement infrastructure upgrades required to service growth and support development in the north-west area of the City. At the time of preparing this report, alternatives have been developed to provide sanitary servicing, however, a preferred alternative has not been selected. Both alternatives include trunk sewers partially aligned on Conservation Drive, Beaver Creek Road, and through proposed development with two (2) new pump stations to convey flow to the Beaver Creek PS. Alternative 1 proposes one (1) pump station on Beaver Creek Road south of Conservation Drive, and one (1) pump station in the area of Snowcrest Place. Alternative 2 proposes one (1) pump station on Beaver Creek Road south of Conservation Drive, and one (1) pump station in the development area east of Erbsville Go-Karts. For the purposes of this Master Plan, the opinion of probable cost for Alternative 2 has been assumed as it provides a more conservative estimate.

2.3.4 Additional Studies

Multiple additional studies have been completed or are on-going that are relevant to the City's sanitary collection system. Below is a list of studies that were reviewed to obtain background information in support of the Master Plan development:

- Sanitary Sewer Flow Monitoring Program - 1993 (Gore & Storrie, 1994)
- Sanitary Sewer Flow Monitoring Program - 1998, Eastbridge on the Grand and Upper Beechwood Subdivisions (CRA, 1999)
- Clair Sewershed I/I Pilot Project (Stantec, 2012)
- City of Waterloo Northland Land Use and Community Improvement Plan Study – June 2012 (MMM Group, 2012)
- City of Waterloo Official Plan – November 21, 2012 (City of Waterloo, 2012)
- City of Waterloo Development Charges Background Study – November 16, 2012 (Hemson Consulting Ltd., 2012)
- Region of Waterloo Wastewater Treatment Master Plan – August 2007 (Earth Tech Canada Inc., 2007)
- Region of Waterloo Water and Wastewater Monitoring Report – May 2012 (Region of Waterloo, 2012)
- Region of Waterloo North Water Supply Class EA Environmental Study Report – December 2011 (AECOM Canada Ltd., 2011)
- Region of Waterloo Rapid Transit Project (AECOM Canada Ltd., 2012)
- City of Kitchener City-wide Sanitary Sewer System Capacity Study(AECOM Canada Ltd., 2011)
- Township of Woolwich, Various Communications/Engineering Drawings re: Stockyards Service Area Tributary to Waterloo

2.4 POTENTIAL IMPACTS OF CLIMATE CHANGE

Under climate change, scientists project that a warming climate will bring increases in the intensity, duration, frequency, and geographic coverage of extreme precipitation, and in Canada an average increase in total annual precipitation (CSA, 2010; TRCA, 2009). In general, potential impacts of future climate change for Ontario include increased frequency of extreme weather such as intense rainfall (especially for shorter storm durations), droughts, freezing rain,

smog events and heat waves (GRCA, 2014). Weather is also likely to be more variable and less predictable from year to year (Expert Panel, 2009).

Since municipal sanitary sewers are designed in part based on historical precipitation information in the form of rainfall intensity-duration-frequency (IDF) curves, it is critical to consider climate change impacts in the design and planning of infrastructure (TRCA, 2009; Simonovic, S. and Peck, A. 2009). Currently, in Ontario, there are no standard approaches to taking climate change effects into account in the stormwater management field and little technical guidance is available from federal/provincial governments or elsewhere on how to account for climate change adaptation (TRCA, 2009). In the absence of specific guidance on climate change adaptation at the municipal level, methods employed by Canadian municipalities can be used as a guideline on best practices for incorporating climate change into planning. These include: 1) modifying IDF curves used for designing infrastructure; 2) increasing safety factors in construction codes and standards to accommodate for additional uncertainty associated with future climate design values; and, 3) taking proactive measures which will mitigate the effects of a range of precipitation conditions by increasing the resiliency of infrastructure, for example through improved stormwater management best practices such as sustainable at-source and low-impact development (LID) techniques. These are three general approaches which are currently being undertaken to deal with the variability in predications of the scope, magnitude, and type of impact on the environment as a result of future climate change (TRCA, 2009).

In 2012, Environment Canada updated the IDF curves across Canada which can be considered more representative of recent temporal and spatial rainfall conditions as they incorporate more recent rainfall data. However, while more recent than the previous IDF curves which were developed decades ago, the method for generating IDF curves is still based on statistical analysis of historical rainfall data and does not explicitly incorporate any projected future trends due to a changing climate (Environment Canada, 2012). There are customizable IDF tools currently being developed to incorporate climate change predictions into historical weather data used to generate IDF curves, however, to date this is only available in draft form and has not yet been implemented for municipal planning or design purposes (Simonovic, S. et al, 2014). Best management practice (BMP) measures to reduce runoff volumes and rates such as rainwater collection and re-use systems, sewer inflow control devices, disconnecting downspouts, green roofs, and land use planning that seeks to increase the amount of pervious area, etc. have a benefit regardless of the degree of climate change.

In general, a trend for overall increased total precipitation and more intense precipitation events over shorter durations can be expected for the City. The potential impacts of climate change in the City were taken into consideration in both the selection of the Design Storm event used for wet weather simulation and in general recommendations for accommodating future climate change in new infrastructure. Additional analysis and evaluation of the potential impacts of climate change on the City sanitary network are detailed in Impacts of *Climate Change on the Waterloo Sanitary Sewer System Master Plan* (Stantec, 2015) in Appendix A.

3.0 MASTER PLAN UPDATE METHODOLOGY

The Master Plan was carried out by the Consultant Team working under the direction of the City of Waterloo Engineering, Integrated Planning and Public Works Department. The Consultant Team worked closely with City staff as part of the Project Team by arranging regular meetings and receiving technical guidance and feedback on deliverables. A stakeholder group was identified and contacted through the project mailing list for notification on the project status and opportunities for public input. The project organization and the overall approach used to complete the 2014 Master Plan Update is described in the following subsections.

3.1 PROJECT ORGANIZATION

The City Project Team provided technical oversight and project management for the Master Plan Update in coordination with the Consultant Team. This included attending meetings, facilitating the transfer of City data to the Consultant Team, and guidance, revisions and feedback on technical models and public consultation material. The City Project Team was also responsible for reviewing and running advertisements for the various Master Plan Notices in local newspapers and updating the City website with information provided by the Consultant Team.

The Consultant Team worked closely with the Project Team Project Manager with regular meetings and communication. The Consultant Team performed the research, analysis, model development, flow monitoring, and reporting for review by the City. The Consultant Team compiled the draft stakeholder lists, notices, advertisements and public consultation materials for the City to review and mailed out the Notices to the Stakeholder list. Overall project organization is presented in Figure 3-1.

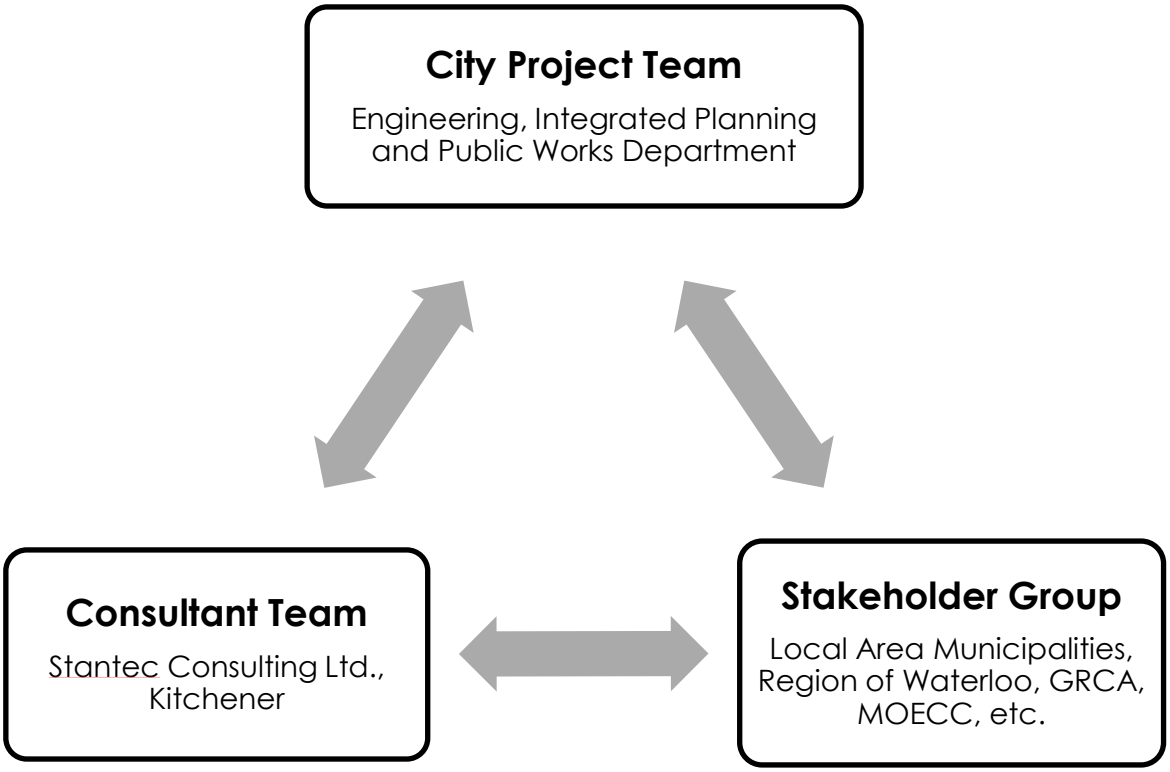

City Project Team
Engineering, Integrated Planning and Public Works Department
Consultant Team
Stantec Consulting Ltd., Kitchener
Stakeholder Group
Local Area Municipalities, Region of Waterloo, GRCA, MOECC, etc.

Figure 3-1: Project Organization

3.2 APPROACH AND CLASS EA MASTER PLANNING PROCESS

The Master Plan Update project was planned and implemented in accordance with the Municipal Class Environmental Assessment (EA) process for Master Plans (Municipal Engineers Association, June 2000, as amended in 2007 and 2011). The completion of the Update satisfies the requirements of Phases 1 and 2 of the Class EA process. An overview of the master planning process was outlined in Section 1.2. Table 3-1 is an outline of the major milestones for the Master Plan Update.

Table 3-1: Master Plan Update Class EA Process with Milestones

Phase 1 (October to November 2013)	
Date	Deliverable
October 2013	Notice of Commencement
November 2013	Notice of PCC No. 1
November 2013	PCC No. 1

Phase 2 (January 2012 to December 2014)	
Date	Deliverable
Development of Collection System Model	
October 2013	Tech Memo No. 1 – Data Verification
January 2014	Tech Memo No. 2 – Data Verification
November 2013	Tech Memo No. 3 – Model Development
November 2013	Tech Memo No. 4 – Model Development
Inflow and Infiltration Study	
December 2013	Draft Tech Memo No. 5 – Evaluate Historical Data
October 2013 to July 2014	Flow Monitoring Program
Master Planning	
February 2015	Tech Memo No. 6 – Evaluate Growth Plans
April 2015	Tech Memo No. 7 – Develop Plan for Capital Needs
March 2014	Notice of PCC No. 2
April 2014	PCC No. 2
April 2014	Draft Final Report
May 2015	Final Report & Notice of Completion
June 2015	Public Review

3.2.1 Technical Memoranda

During the process of developing the Master Plan, seven (7) technical memorandums (Tech Memos) were prepared for the Master Plan Update. A brief description of each tech memo is summarized herein.

Outside of the workshops, several key project meetings were held with the project team and various stakeholders over the project duration to obtain information. For example, meetings were held with the neighbouring Area Municipalities and the Region to obtain data regarding existing and future external flows to the City collection system. Note that the Consultant Team will also conduct a workshop to train designated City staff on the capability, components and usage of the hydraulic model, separate from the master planning process. The Tech Memos are summarized below.

Tech Memo No. 1 partially satisfies Task 1 of the Master Plan and summarizes and documents the review of data for use in developing a sanitary system model and improving available GIS data. Task 1 includes data review and validation of the existing sanitary system and the development

of a current state geodatabase for model input. Data provided for Task 1 includes physical attributes required for hydraulic modeling and surface area data to support model loading. The data review completed for Tech Memo 1 includes two (2) forms: gap assessment and data confidence for model application. The data review was undertaken in GIS in both ESRI ArcMap and hydraulic modeling software utilizing their built-in analysis tools. The sewer data provided from the City was provided in a geodatabase format that was subsequently converted into individual shapefiles for transfer to the modeling environment. Details regarding the data review and verification process are documented in Tech Memo 1 presented in Section 6.0. Tech Memo 1 is provided in Volume 2, Appendix E.

Tech Memo No. 2 completes Task 1 of the Master Plan and summarizes how the infrastructure data will be integrated into the selected model software, and outline additional modeling information that will be required. The model software selected for the purposes of the Master Plan, based on the Model Needs Assessment, is PCSWMM. Details of Tech Memo 2 are presented in Section 6.0. Tech Memo 2 is provided in Volume 2, Appendix F.

Tech Memo No. 3 satisfies Task 2 of the Master Plan and summarizes the information collected from relevant staff and organizations at this particular stage in the project. Task 2 was intended to provide the basis for defining the needs and methodology, evaluating options and selecting a preferred hydraulic modeling tool that best suit the needs of the City. Information was solicited from City staff, organizations that have gone through a similar process, and software vendors to evaluate and select a preferred software and model development methodology. The outcome of Task 2 was used in conjunction with the updated system data obtained from Task 1 to complete Task 4 - Hydraulic Model Development, Train, and Implement. Tech Memo 3 is provided in Volume 2, Appendix G.

Tech Memo No. 4 satisfies Task 3 of the Master Plan. Task 3 was intended to evaluate the net benefit of the City purchasing and implementing the preferred hydraulic model, PCSWMM. Both financial and non-financial factors were considered, including short and long term financial costs, access to technical expertise, staffing requirements, service levels, as well as utilization of assets, future opportunities, and faster implementation of projects. Details of Tech Memo 4 are presented in Section 6.0. Tech Memo 4 is provided in Volume 2, Appendix H.

Tech Memo No. 5 satisfies Task 5 of the Master Plan and summarizes the results and methodology for sanitary sewer flow monitoring. The purpose of Task 5 was to summarize the historic flow monitoring data and I/I results of the past, alongside the recent flow monitoring data for 2013/2014. In addition, Task 5 was used to help identify strategic flow monitoring locations to assist both model calibration and I/I characteristics. Details of Tech Memo 5 are presented in Section 6.0. Tech Memo 5 is provided in Volume 2, Appendix I.

Tech Memo No. 6 satisfies Task 4 of the Master Plan which includes the development and implementation of the hydraulic model to be used in the assessment of existing and future conditions. The purpose of this Tech Memo was to outline the model development process, including the input data sources and the model calibration and validation process. A summary

was also provided for the methodology for assessing the performance of the system and procedures for updating the model for future use. Key results of Tech Memo 6 are presented in Section 6.0. Tech Memo 6 is provided in Volume 2, Appendix J.

Tech Memo No. 7 satisfies Task 7 of the Master Plan which was to assess existing and future conditions to identify recommended upgrades. The purpose of this Tech Memo was to outline the capacity analysis and needs assessment, identification and evaluation of alternatives and recommendations, and selection of preferred alternatives. Preliminary staging and implementation recommendations are also provided. Results from the Draft Tech Memo No. 7 were used to develop the Public Consultation Material and the key results are presented in Section 7.0. Tech Memo 7 is provided in Volume 2, Appendix K.

3.3 PUBLIC, AGENCY AND STAKEHOLDER CONSULTATION

3.3.1 Overview of Public and Agency Consultation Program

The public and agency consultation of the City-Wide Sanitary Sewer Study Master Plan Update followed the Class Environmental Master Planning Process and included the following:

- Public and Agency Notifications
- Project Mailing List
- Public Consultation Centres

A master list of project stakeholders was developed to make up the Project Mailing List. A Notice of Commencement was mailed out October 18, 2013 to the stakeholders on the project mailing list and was advertised in local newspapers and on the City website starting on October 18, 2013.

Two (2) Public Consultation Centres (PCCs) were held for this project in November 2013 and April 2015.

The Notice of Public Consultation Centres ran in local newspapers and on the City website (http://www.waterloo.ca/sanitarymasterplan) starting two (2) weeks prior to the PCC date (Section 5.5). In addition, a Notice of PCC letter was mailed to each stakeholder association on the stakeholders mailing list. The full list can be found in Appendix B. All project notices included description of the project and contact information of the project team to enable members of the public to request further information and ask questions.

Further details on the public and agency consultation are summarized in the following sections, with all distributed materials and associated documentation included in Appendix B.

3.3.2 Notice of Commencement

A Notice of Commencement was advertised in the KW Record and the Waterloo Chronicle on their respective issue dates in October 2013. The Notice of Commencement was also posted on the City's website during the week of October 18, 2013. The advertisement and letter are provided in Appendix B.

Federal, provincial and municipal agencies and other local stakeholders were also notified by letter dated October 18, 2013. The list of agency and stakeholder contacts and the Notice of Commencement letter is provided in Appendix B.

Two (2) agencies (Ministry of Aboriginal Affairs, Ministry of the Environment and Climate Change) responded to the mail-out Notice of Commencement letter providing additional information regarding the Aboriginal groups within the area and the consultation requirements. Agency responses to the Notice of Commencement letter are summarized in Table 3-2 and included in Appendix B.

Table 3-2: Comments in Response to Notice of Commencement

Organization	Name	Date Received	Comment
Response to Notice of Commencement Letter			
Ministry of Aboriginal Affairs	Heather Levecque	December 6, 2013	• Discussed various Aboriginal Groups within the Project Area.
Ministry of the Environment	Barbara Slattery	August 28, 2014	• Discussed requirements to consult.

3.3.3 Notice of Public Consultation Centres

The Public Consultation Centres (PCCs) were advertised for two (2) weeks in advance of the events in the following newspapers:

PCC #1

- Waterloo Chronicle October 2013
- The KW Record October 2013

PCC #2

- Waterloo Chronicle Wednesday, March 25, and Wednesday, April 1, 2015
- The KW Record Saturday, March 28, and Saturday, April 4, 2015

The Notice of PCC advertisement which appeared in the above newspapers is included in Appendix B. A Notice of PCC was also sent to those on the project mailing list.

3.3.4 Notice of Completion

A Notice of Completion, indicating the completion of the Master Plan Update and the availability of the Final Report for public review and comment will be published in the following newspapers:

- Waterloo Chronicle
- The KW Record

A Notice of Completion will also be mailed out to all those on the project mailing list.

3.3.5 Public Consultation Centres

Two (2) Public Consultation Centres (PCCs) were held in the City of Waterloo. The PCCs provided an opportunity for the public and stakeholders to review the results of the work completed to date, including the preliminary preferred City-Wide Sanitary Sewer Study Master Plan Update, discuss with the City Project Team and Consultant Project Team, and to obtain comments and feedback which the Project Team will take into consideration prior to the completion of the Update. The PCCs were held on the dates and locations provided in Table 3-3. The Notice of PCC was outlined in Section 3.3.3.

Table 3-3: Master Plan Update PCC Locations and Dates

Date	Time	Location
November 27, 2013	5:00 – 7:00 PM	Waterloo Memorial Recreation Complex, Bauer Room 202, from 5:00 PM - 7:00 PM
April 8, 2015	5:00 – 7:00 PM	Waterloo Memorial Recreation Complex, Kiwanis Room 201, from 5:00 PM - 7:00 PM

The City Project Team staff and Consultant Team staff were available to answer questions and direct the public to the sign-in and comment sheets. A handout describing the project was available and a printout of the PCC boards on display was supplied to attendees. Six (6) people attended PCC #1, and seven (7) people attended PCC #2. The PCC board materials are included in Appendix B.

Comment sheets were provided at both of the PCCs; however, no submissions of comments were received.

3.4 EVALUATION CRITERIA

3.4.1 Methodology

The recommended servicing alternatives presented in Section 6.1 were evaluated and ranked based on a set of evaluation criteria. The evaluation criteria guided the assessment of servicing alternatives based on their impacts to the natural, social, and economic environments. The evaluation criteria are presented in the following section. Table 3-4 outlines the ranking scale for criteria with good to poor range.

Table 3-4: Criteria Ranking Scale

Rating	Criteria Ranking	Numeric Score
Good		1.0
		0.75
Neutral		0.50
		0.25
Poor		0

The criteria are all weighted equally. Based on the ranking of the alternatives, the final score in combination with staging considerations was used to select the recommended alternatives and prioritize implementation of projects.

3.4.2 Evaluation Criteria

The selection of the evaluation criteria were informed by the 2002 MP and the Municipal Class Environmental Assessment guidance document, and were finalized through consensus with the City Project Team. Table 3-5 outlines the criteria used for the evaluation of the recommended servicing alternatives.

Table 3-5: Evaluation Criteria

Category	Criteria	Description
Technical	Hydraulic Improvements	Ability for the alternative to provide an improvement to long term hydraulic constraints.
	Operations and Maintenance	Ranking of ongoing equipment operations and maintenance (pumps stations) versus collections upgrades (pipes).
	System Resiliency	Ability for upgrade to provide level of service under wet weather conditions.
Ease of Implementation	Constructability	Ease of construction for upgrades.
	Regulatory Considerations	Ease of obtaining the necessary regulatory approvals and Source Water Protection requirements.
Social	Impact for Surrounding Residents	Proximity to residents that may be impacted by noise, construction activities, and increased traffic.
System Suitability	Consistency with Planned Upgrades	Potential to coordinate with other planned works (roads, etc.) and achieve multiple planning objectives.
	Consistency with Operating Strategies	Ability for alternative to align with current operational practices.
Environment/ Sustainability	Carbon Footprint	Ability for alternative to minimize the carbon footprint of works (relining existing pipes vs addition of new pipes).
	Impact on Terrestrial/ Aquatic Systems	Potential for and/or severity of impacts to terrestrial and/or aquatic systems based on alignment (pipe) or footprint (pump station).
Financial	Capital Cost	Capital cost to implement the proposed alternative.
	Operating and Maintenance Cost	Cost to operate and maintain the proposed alternative over its lifecycle.

4.0 STUDY AREA INVENTORY

4.1 PLANNING SCENARIOS

The purpose of the 2014 Master Plan is to identify infrastructure upgrades required to accommodate anticipated population growth to a planning horizon of 2031. Planning scenarios have been established in 5 year increments; 2014, 2019, 2024, and 2029. Anticipated population growth has been established for each planning horizon, and any anticipated infrastructure upgrades have been accounted for within the scenarios based on anticipated staging.

The recommendations include Priority Projects and Strategic Projects, which are established in five (5) year increments coinciding with the planning scenarios.

4.2 POPULATION PROJECTIONS

4.2.1 Existing Populations

Population data was established for 2011 (current/base conditions), and categorized into residential, employment (ICI). Student populations (On Campus and Off-Campus) groupings have been included in the residential population.

Residential and ICI populations established for the current/base conditions were based on the 2011 Census data, and the on- and off-campus student population was derived from the *Development Charges Background Study* (Hemson Consulting Ltd., 2012). The City-wide populations are summarized in Table 4-1 for the current conditions. Populations were spatially distributed based on dissemination areas, MPAC codes, stormwater rate classification, and sense-checks for expected flow-rates.

Table 4-1: Overview of Current Population

Planning Period	Population	
	Residential[1]	Employment
Existing Conditions (2011)	120,453	63,473

Note 1: Residential population figures presented include the on- and off-campus student population.

The student population is not captured within the Census; therefore, the student population provided in the Development Charges Background Study (Hemson, 2012) was used. Student populations were spatially allocated through interpretation of the residential population and the water meter records; areas of artificially low population due to the omission of students were identified. Student populations were allocated to these areas, which tended to be near the two (2) universities.

4.2.2 Future Population

Population data was established for each of the intermediate planning horizons 2014, 2019, 2024, and 2029 scenarios and categorized into residential, employment (ICI), and student populations (On Campus and Off-Campus) groupings. Table 4-2 provides a summary of the population for the different model scenarios.

Table 4-2: Overview of Forecasted Population by Planning Period

Planning Period	Population	
	Residential[1]	Employment
Existing Conditions (2011)	120,453	63,473
2014	126,044	63,661
2019	135,932	72,721
2024	146,573	79,429
2029	152,613	90,368

Note 1: Residential population figures presented include the on- and off-campus student population.

The population growth values were provided up to year 2024 within the *Development Charges Background Study* for residential, ICI, and on-campus and off-campus students (Hemson Consulting Ltd., 2012). The spatial allocation of population growth was focused in two distinct areas: Greenfield development on the periphery of the City, and intensification in the Core Area. The growth in Greenfield areas was allocated based on the *City of Waterloo Staging of Development Report 2011-2014* (City of Waterloo, 2011), and intensification in the Core Area was allocated along the proposed Light Rail Transit (LRT) route. The student population growth was assumed to be in the same locations exhibiting high student populations under existing conditions. Decisions on the spatial distribution were made in consultation with the City and are detailed in Tech Memos 6 and 7 in Volume 2, Appendices J and K respectively.

The population forecasts for the 2029 planning horizon were based on the *City-Wide Growth Forecast* (nblc, BrookMcIlroy, and CH2M Hill, 2014). The spatial allocation of population growth in 2029 was focused on four distinct areas: 1) Designated Greenfield; 2) Nodes & Corridors; 3) Remaining City Lands; and, 4) Station Areas. The growth in the Designated Greenfields, Nodes and Corridors, and Remaining City Lands was allocated based on the *Staging of Development Report 2011-2014* (City of Waterloo, 2011) and the *City Official Plan* (City of Waterloo, 2014). Growth within the Station Areas was allocated based on a development capacity assessment provided by the City.

4.3 GROWTH AREAS

4.3.1 Greenfield Development Areas

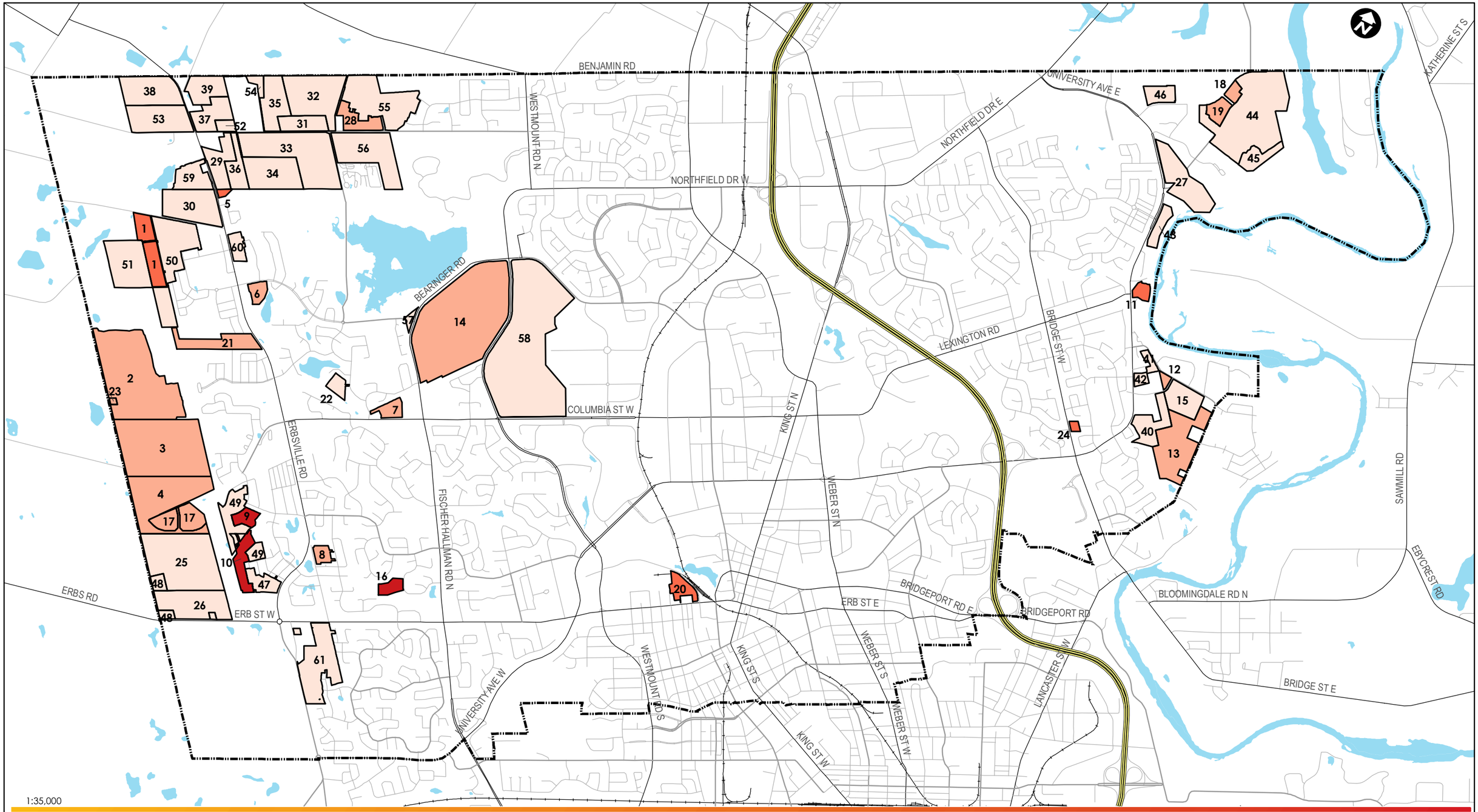
Greenfield development areas were identified for the Master Plan based on the following two sources: the *Staging of Development Report 2011-2014* (City of Waterloo, 2011) and additional Designated Greenfield areas identified in the *City-Wide Growth Forecast* (nblc, BrookMcIlroy, and CH2M Hill, 2014) that were beyond the planning period of the Staging of Development Report. The *Staging of Development Report 2011-2014* identified 39 developable lands sites and provided the anticipated type of dwellings and the projected number of units. Persons per unit (PPU) rates outlined in the District Plans (provided via email correspondence with the City, April 29, 2014) were used in conjunction with the information in the Staging of Development Report to calculate the future residential population for each planning period/model scenario (2014, 2019, 2024, and 2029). Additional Designated Greenfield areas were identified in the *City-Wide Growth Forecast*. A map of the Greenfield areas is provided in Figure 4-1, grouped by serviceability.

The Beaver Creek development area is located in the northwest and western areas of the City, and are referred to as Beaver Creek (refer to Parcel IDs 28, 29, 31-39 in Figure 4-1) and West Waterloo (refer to Parcel IDs 2-4,17, 23 in Figure 4-1), respectively. Servicing to West Waterloo was previously identified by extending a trunk sewer from Columbia Forest Court (referred to as Cedar Trunk 2 (West) Extension) through ESPA 19 in accordance with *West Side Trunk Sanitary Sewer - South Branch Class EA* (1996) and *City Wide Sanitary Sewer System Update Master Plan Class EA* (AECOM, 2002). This trunk extension was installed between 2007 and 2013 and additional servicing required to accommodate growth would be associated with the construction of local sewers. Development within Beaver Creek is to be provided through the construction of new trunk sewers and two new sanitary pump stations. The *Conservation Drive and Beaver Creek Road Upgrades and Extension of Municipal Services Class EA* (Stantec, ongoing) is currently in progress to confirm the location of proposed infrastructure.

4.3.2 Infill and Intensification

Infill and intensification will occur throughout the City as existing areas are redeveloped with higher population densities. The area projected to experience the most significant infill and intensification is in the vicinity of Uptown Waterloo within the planning area referred to as the Core Area.

The population growth in the Core Area was assumed to be concentrated along the proposed LRT route; therefore, the growth was allocated to parcels along this corridor. The majority of the increases in ICI population were allocated to existing ICI properties, 50% within the Core Area, and 50% to remaining areas within the City.



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Legend

- Development Area with ID Number

Completion Timeframe (estimated)

- 2014
- 2019
- 2024
- 2029

Figure No. FIGURE 4-1

Title **PROPOSED DEVELOPMENT AND ADDITIONAL GREENFIELD AREAS**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE

4.3.3 Properties on Private Services

Properties currently provided with private sanitary servicing were also reviewed to evaluate the feasibility of providing municipal servicing. Municipal servicing could be provided to the majority of these parcels through an extension of local sewers and conveying flows by gravity. However some properties cannot be serviced by gravity and will require a pump station or grinder pump. These servicing strategies are discussed in greater detail in Section 6.5.1.

It is noted that several properties on private sanitary services are located in the Beaver Creek development area. As part of the extension of municipal services to accommodate proposed development, upgrades could be coordinated to provide municipal servicing to existing residents at the same time.

4.4 INTER-MUNICIPAL SERVICING AGREEMENTS

The sanitary network receives flows from various sources outside the City's boundaries, as mentioned in Section 2.1. Figure 2-1 illustrates the location of the external contributions, which include the following sources:

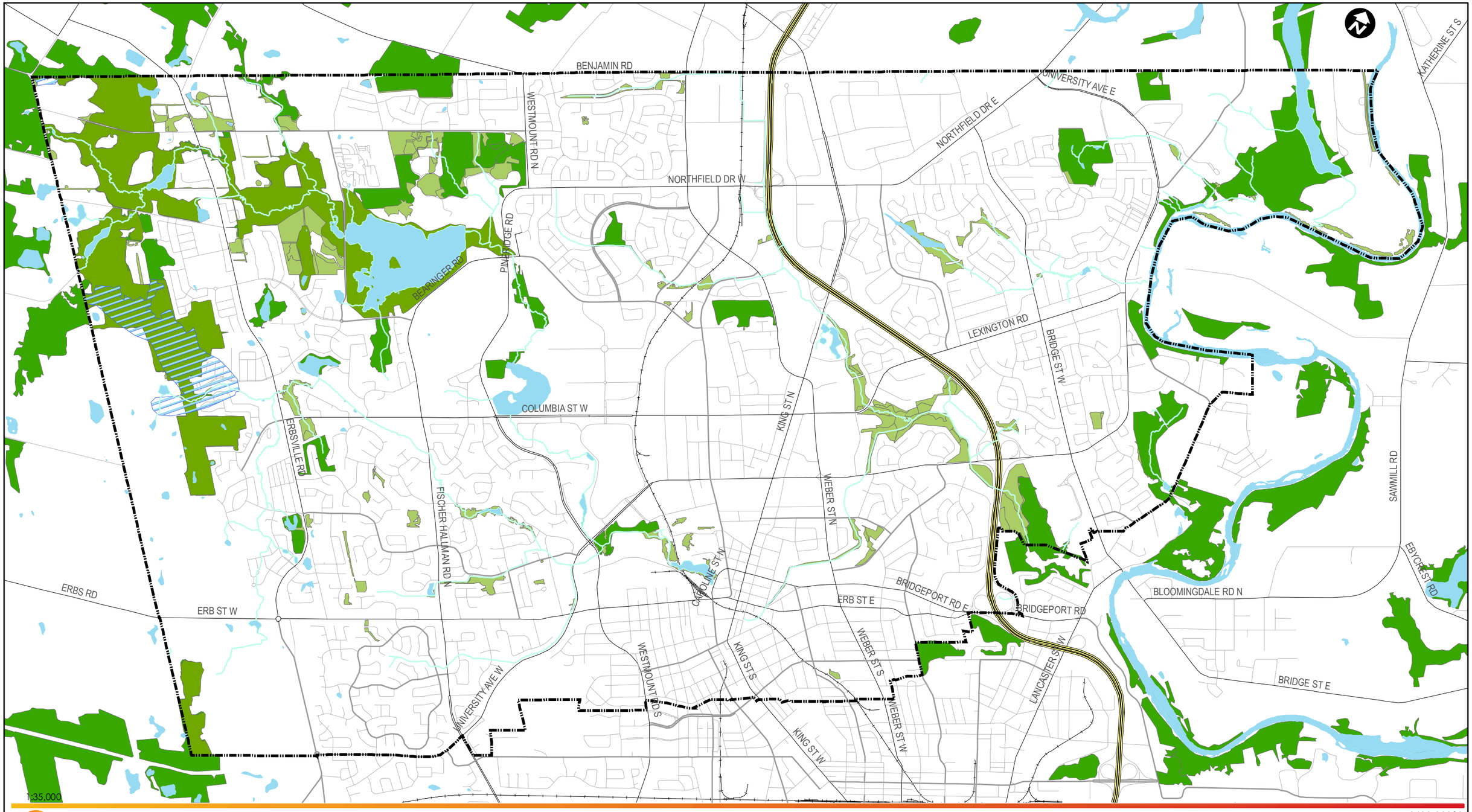
- Inflows flows from the St. Jacob's Farmers Market and Stockyards area
- Inflows from Falconridge Pump Station (PS) (located in Kitchener)
- Inflows from Bridgeport Pump Station (PS) (located in Kitchener)

The flows from these sources have been incorporated into the sanitary hydraulic model, and are discussed in greater detail in Section 5.4.

4.5 NATURAL, SOCIAL, AND ECONOMIC FEATURES

As part of the evaluation of alternatives, the natural, social, and economic impacts will be taken into consideration to evaluate alternatives and identify preferred solutions. To support this evaluation process, a desktop inventory was completed for natural, social, and economic features.

Natural features identified for consideration in the evaluation process included: water bodies, wetlands, floodplains, woodlands, wellhead protection areas, and well recharge areas. Figure 4-2 provides a map of the natural features identified within the City.



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- Creek
- Water Body
- Regional Recharge Area
- Environmental Lands
- Natural Feature
- Region Forest

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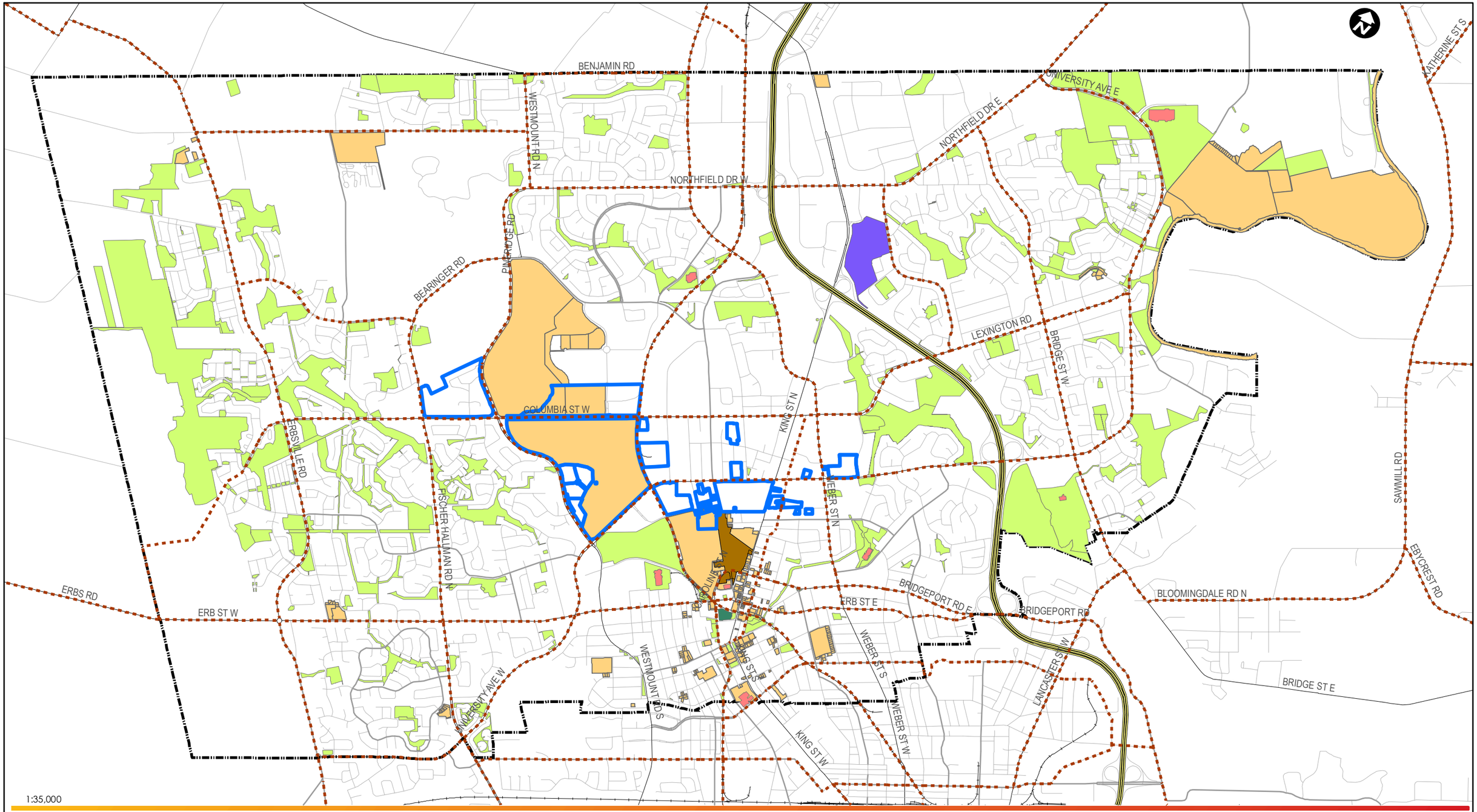
Figure No. FIGURE 4-2

Title **NATURAL FEATURES**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE

Social, heritage, and archaeological features identified for consideration include designated heritage buildings, areas of archaeological potential, parks, shopping centers, universities and colleges, and community centers (including recreational complexes and libraries). Figure 4-3 provides a map of the social and heritage features identified within the City. The archaeological potential has been provided by the Region, and is indicated in Figure 4-4.

Economic features for consideration in the evaluation process included: urban growth areas, LRT Station Locations, LRT Station Areas, and areas of existing ICI land uses. Urban growth areas were identified based on areas of expected infill and intensification within the Uptown Waterloo area. LRT Station Areas represent the surrounding land that is considered to be within a 10 minute walk from the station (approximately 800 m). Areas of commercial, institutional, and industrial land uses were identified based on existing land use zoning. Figure 4-5 provides a map of the economic features identified within the City.



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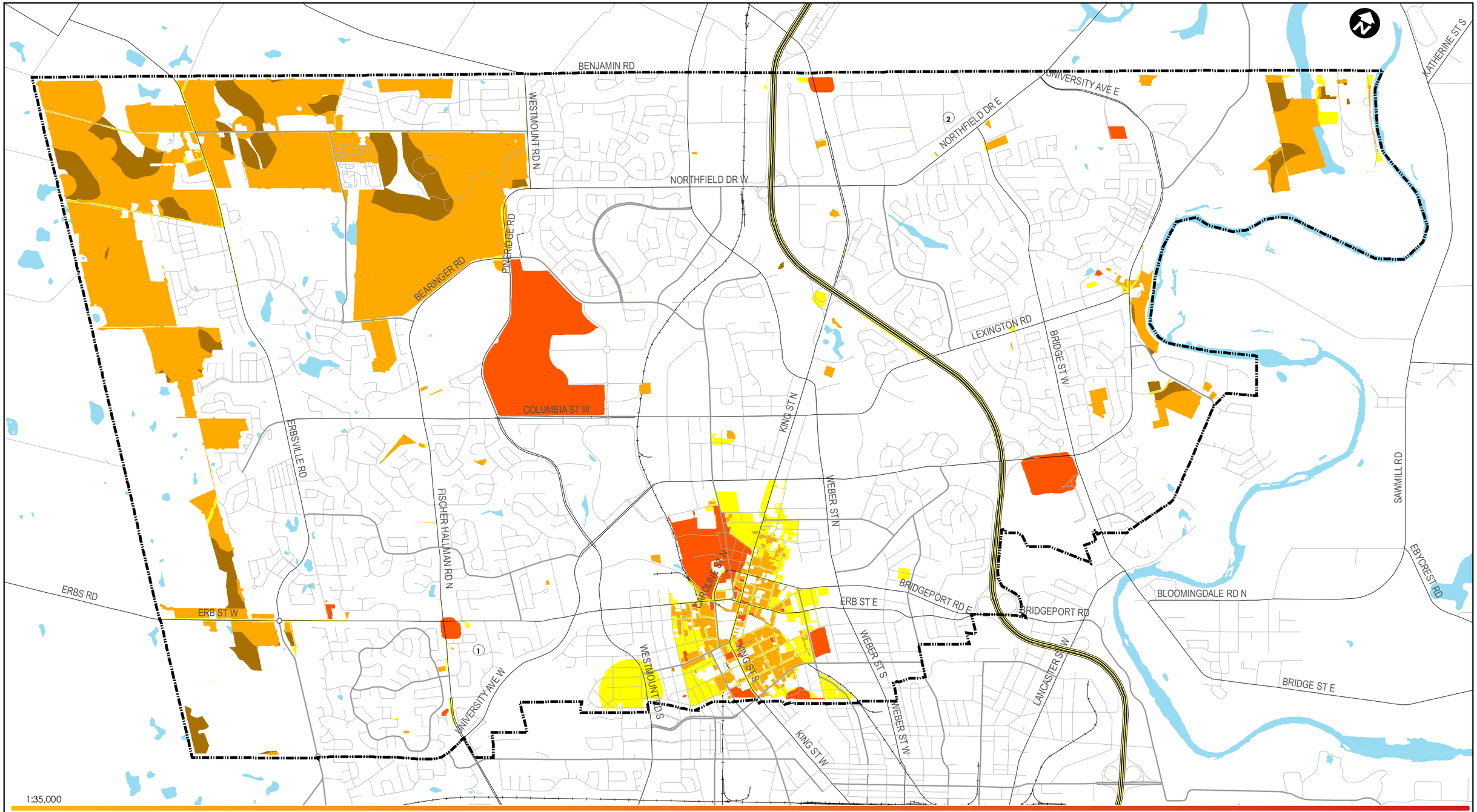
Legend

- Cycle Routes
- Parks
- Heritage District
- Heritage Properties
- Community Centre
- University / College
- Conestoga Mall
- Waterloo Town Square

Figure No. FIGURE 4-3

Title **SOCIAL FEATURES**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE



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Assessment Potential

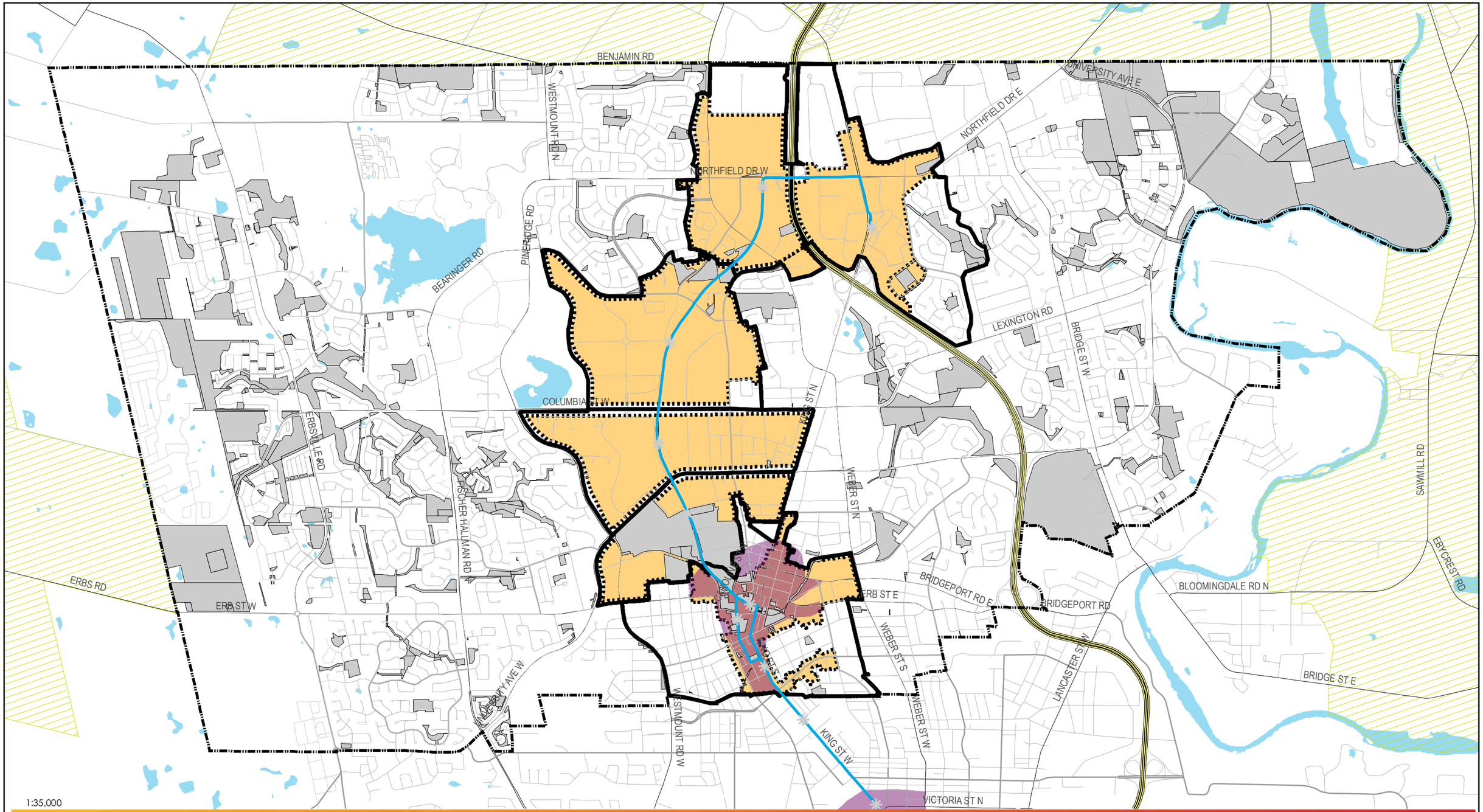
- Assessment Always Required
- Assessment Required
- Assessment Required - Except Consents
- Assessment Possibly Required
- Assessment Not Required

Assessment Potential information derived from Region of Waterloo mapping (2015).

Figure No. FIGURE 4-4

Title **ARCHAEOLOGICAL ASSESSMENT POTENTIAL**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE



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Legend

- Rapid Transit Stations
- Rapid Transit Route
- LRT Study Area
- Conceptual Station Area
- Prime Agriculture
- Urban Growth Centre
- City Owned Lands

1611-11191

Figure No. FIGURE 4-5

Title **ECONOMIC CONTRIBUTIONS**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE

5.0 HYDRAULIC MODEL DEVELOPMENT

A sanitary hydraulic model has been developed as a tool for assessing the capacity of the existing and proposed infrastructure to accommodate the anticipated growth in population.

5.1 SANITARY HYDRAULIC MODEL APPROACH

A Hydraulic Needs Assessment was completed which provided the basis for defining the software and approach for developing a hydraulic model that best suited the needs of the City. Information was solicited from City staff, organizations that have gone through a similar process, and software vendors to evaluate and select a preferred software and model development methodology. Details regarding the Hydraulic Needs Assessment are provided in Tech Memo 3 (refer to Volume 2, Appendix G).

Based on the Hydraulic Needs Assessment (Tech Memo 3 – Volume 2, Appendix G), the intended model use for future activities would be primarily for capacity assessments associated with development application.

The outcome of the Hydraulic Needs Assessment indicated the preferred approach was to develop a dynamic model that includes all pipes within the Core Area and sewers defined as trunks or sub-trunks for the remaining area of the City. Long-term, the City has identified a goal of transitioning to an all-pipes model throughout the City. The selected software for developing the hydraulic model was PCSWMM.

As part of the Hydraulic Needs Assessment, the City expressed the preference for the model to be maintained and updated in-house, with external consultants only being utilized as necessary. A benefit/cost assessment was completed to evaluate the net benefit of the City purchasing the model software and maintaining and operating the hydraulic model. Details of the cost/benefit assessment can be found in Tech Memo 4 (refer to Volume 2, Appendix H). Based on the assessment, there is both an economic and non-financial net benefit in support of the City to own, operate, and maintain the hydraulic model, however, this would require dedication from management and internal staff to the development and continued application of a structure and associated processes to maintain the long-term successful use of this tool. It was therefore recommended the City undertake a review of their internal workload needs along with available internal funding sources to further evaluate the long-term organizational and financial viability of dedicated staffing for model-related activities.

5.2 REVIEW OF GEODATABASE

During model development, the physical network of sewers, manholes, and pump stations was established based on the City's internal database. This physical network becomes the underlying framework for the model; therefore, it is crucial that the infrastructure is reviewed for completeness and proper connectivity.

A review of the existing sanitary GIS database was completed prior to model development which provides quality enhancements to the sanitary GIS data. The review includes two (2) forms: gap assessment and data confidence for model application. The data review was undertaken in GIS in both ESRI ArcMap and hydraulic modeling software utilizing the built-in analysis tools.

Missing and inconsistent data identified within the physical network is summarized in Tech Memo 1 (Volume 2, Appendix E). This data included manhole inverts and rim elevations, and sewer diameters, slopes and inverts. In addition, a review was conducted of the hydraulic continuity and suitability of physical sewer data in terms of profile connectivity.

The missing and inconsistent data was prioritized such that trunk sewers were assigned the highest priority, sub-trunks were assigned a medium priority, and local sewers were assigned the lower priority. A data verification program was developed to obtain the missing or inconsistent data in an efficient manner, through the use of drawing review, field verification, and inference. As a final resort, data was inferred based on the surrounding network. The verification program is summarized below:

Trunk Sewer Data Verification (Priority 1):

1. Drawing review.
2. Field work, if required, for outstanding gaps or uncertainties.
3. Infer data if required.

Sub-trunk Sewer Data Verification (Priority 2):

1. Drawing review for areas of greater uncertainty (dependent on remaining resources).
2. Infer data.

Local Sewer Data Verification (Priority 3):

1. Infer data (extent will be dependent on model needs).

Additional information can be found in Tech Memo 1 (Volume 2, Appendix E) regarding the identification and prioritization of missing and inconsistent data, or the field program, drawing review and inference of data.

5.3 FLOW MONITORING LOCATIONS

The sanitary hydraulic model was calibrated and validated through comparison to the observed flow monitoring data collected throughout 2013 and 2014. A total of 15 flow monitors were used for model development and calibration. These flow monitors are presented in Figure 5-1.

FROBISHER PS
NORTHLANDS PS
MILLENIUM PS
COLONIAL PS
MALABAR PS
FALCONRIDGE PS
BRIDGEPORT REGIONAL PS
BEAVER CREEK PS
FWL-50
FWL-22
LWD-6
CBA-12
KEA-30
LRL-56
L31-3
WLM-1B
MPL-63
FWL-4A
WTP
GLN-4
LEE-9
LEX-8A
UNI-4
LRL-19

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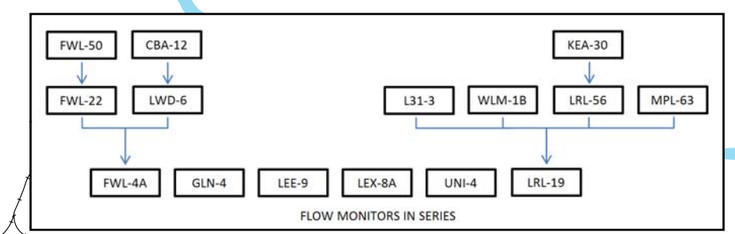

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Legend

- Existing Pump Station
- Forcemain
- Wastewater Treatment Plant

All Sanitary Sewers
- Local Sewer
- Trunk Sewer

Model Selection Set
- Local Sewer
- Trunk Sewer

Current Flow Monitors
- Existing Monitors
- Existing Monitors (Removed)

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Figure No. FIG-5-1

Title **CURRENT FLOW MONITOR COVERAGE**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE

5.4 INTER-MUNICIPAL SERVICING AGREEMENTS

The sanitary network receives flows from various sources outside the City's boundaries, as discussed in Section 4.4. Figure 2-1 illustrates the location of the external contributions. The flows from these sources have been incorporated into the sanitary hydraulic model in the respective scenario. The external sources of sewage flow are listed below:

- Inflows flows from the St. Jacob's Farmers Market and Stockyards area
- Inflows from Falconridge PS (located in Kitchener)
- Inflows from Bridgeport PS (located in Kitchener)

5.4.1 Leachate Inputs

The Region of Waterloo Waste Management Site collects and pumps leachate into the City's Sanitary Network along Ira Needles Blvd. The current agreement between the Region and the City restricts the discharge to a maximum flow rate of 7.6 L/s of leachate discharge into the City's Network, which implies that the two pumps are not run concurrently. The agreement between the Region and the City regarding the leachate discharge is currently being updated. The increase in flow is expected to come into effect in between 2017 and 2019; however, there is the potential for it to be implemented earlier. As a conservative measure, a maximum rate of 15.2 L/s has been applied for each of the planning horizons (2014, 2019, 2024, and 2029).

5.4.1.1 Township of Woolwich Stockyards Area Input

The Stockyards Area includes a portion of the Village of St. Jacobs, and drains into the City of Waterloo Sanitary Network. Three sources of information were used to determine flow inputs for the Stockyards area: peak and baseline flows from the Township of Woolwich (Township) (refer to Tech Memo 6 – Volume 2, Appendix J), diurnal patterns from flow monitoring completed in 2011, and the diurnal pattern from the 2013 flow monitoring.

The St. Jacob's WWTP is expected to be decommissioned by year 2029, and the flows will be diverted to the City of Waterloo Sanitary Network. Anticipated inflows from this location have been developed based on the 2013 Water and Wastewater Monitoring Report (Region of Waterloo, 2013). This flow was applied to model node 11904 (Manhole FWL-43), and have been included in both the 2024 and 2029 Model scenario to be conservative. The applied flows represent the anticipated average sewage generation within the upstream catchment area; however, the received flows may be higher than the estimated rate due to uncertainties regarding the future operation of the site (ie. equalization tanks, pumping rates). Additional analyses may be required to further establish flows at this location. A summary of the applied flows can be seen in Table 5-1.

Table 5-1: Township of Woolwich Stockyards Area Inputs for Existing and Future Model

Location	Results
MH 15639 (F38-4B)	ADSF ranges from 2.9 to 4.4 L/s, Baseflow ranges from 1.2 to 1.8 L/s
MH 11908 (F47-1)	ADSF is 2.3 L/s, Baseflow is 2.8 L/s
MH 11904 (FWL-43) Flows from St. Jacob's WWTP	2024 is 14.8 L/s 2029 is 16.12 L/s

Note: 2013 Water and Wastewater Monitoring Report (Region of Waterloo, 2013).

5.4.1.2 Falconridge Pumping Station (City of Kitchener)

The Falconridge PS is owned by and situated within the City of Kitchener. The catchment area is mostly within Kitchener with a small area from Waterloo contributing to the pump station. A peak flow of 12.97 L/s was reported for the Falconridge PS in the *City-wide Sanitary Sewer System Capacity Study* completed by AECOM in 2011 for the City of Kitchener. Because SCADA records were not available for the Falconridge PS, a timeseries could not be used. The peak flow of 12.97 L/s as reported in the AECOM report (2011) was applied as an average sewage flow. The diurnal pattern derived from the downstream flow monitor (LEX-8A) was applied to the average sewage flow, which provides a conservative representation of the forcemain discharge.

The inflows from Falconridge Pump Station (PS) applied to the model scenarios range from 12.97 L/s in the Current State to 25.97 L/s in 2029 As indicated in the *City-wide Sanitary Sewer System Capacity Study* completed by AECOM in 2011 for the City of Kitchener.

5.4.1.3 Bridgeport Pump Station (Region of Waterloo)

The Bridgeport PS is owned by the Region of Waterloo, and is situated within the City of Kitchener. The catchment area is mostly within Kitchener with a small area from Waterloo contributing to the pump station. The Region provided 2013 SCADA historical flow records. The SCADA recorded flows were input into the model as a timeseries of direct sewage inflow the discharge location during calibration and validation. The timeseries was used as a model input at this time; full dry and wet weather simulation of the tributary area to Bridgeport is outside the scope of this Master Plan.

The growth in the catchments upstream of the Bridgeport PS is uncertain, therefore, the firm capacity of the pump station was applied for all future scenarios (2014, 2019, 2024, and 2029) to provide a conservative approach. The firm capacity of the pump station is 273 L/s, as per the Certificate of Approval (CofA).

5.5 HYDRAULIC MODEL CALIBRATION

5.5.1 Dry Weather Calibration

Dry weather flow (DWF) calibration was completed by running model simulations for various dry weather periods. DWF calibration included inputs such as sewage loading and groundwater infiltration allowance, with consideration for weekday and weekend flow patterns. The model results at each monitor site were compared to the "observed" monitored flow for the time period.

The parameters were varied in a systematic manner within a reasonable range until an acceptable fit to the observed flow was obtained. Comparisons were made between modeled versus monitored flow, depth, volume, and velocity, with a targeted level of accuracy was +/- 20%. The flow and volumes for DWF were found to compare well, confirming the pipe connectivity and an acceptable delineation of subcatchment areas. Additional details regarding calibration can be found in Tech Memo 6 (Volume 2, Appendix J).

5.5.2 Wet Weather Calibration

The validated DWF sanitary system model was then used to perform the wet weather calibration/validation to monitored wet weather flow (WWF) events. Wet weather calibration has been completed using the RTK method, which is an event based approach. The RTK unit hydrograph method is a widely accepted approach to WWF. The RTK method generates the total I/I into the sanitary sewer system by combining triangular unit hydrographs from three components of flow: rapid inflow, moderate infiltration, and slow infiltration. Details can be found in Tech Memo 6 (refer to Volume 2, Appendix J).

A selection of observed rainfall events were established which overlap with the 2013/2014 flow monitoring period. Parameters were input to the hydraulic model on a trial basis and the routed flow hydrographs produced by the model at each monitor site were compared to the "observed" monitored flow.

Calibration included modification to parameters such as sewage generation rates, contributing area characteristics (population, connectivity, etc.), and RTK values. Comparisons were made between modeled versus monitored flow, depth, volume, and velocity, with a targeted level of accuracy of +/- 20%.

Overall, the wet weather response is replicated well in the model, with some variability between calibration events. This can be attributed to the application of average uniform parameters to differing types of events (e.g. duration, intensity), and is to be expected. For the purposes of this study, the capture of extreme events is considered acceptable, and the calibration/validation process confirms the general pipe connectivity and contributing sewage and wet weather generation rates. Additional details regarding calibration can be found in Tech Memo 6 (Volume 2, Appendix J).

5.5.3 On-Going Calibration

On-going calibration is recommended by the City to ensure the model is up-to-date for potential future uses. Updates are continuously being made to the physical infrastructure geodatabases and should be reviewed and incorporated into the model as appropriate. In addition, dry weather flow and wet weather flows should be reviewed and the loading data adjusted as necessary based on future flow monitoring data. As part of the City's flow monitoring efforts, locations could be strategically selected to focus on areas of interest to ensure the model is accurate for more localized areas.

As the City progresses towards a full-pipe model, population and flow allocations will need to be updated. In a sub-trunk/trunk level model, upstream populations and flow rates are combined and applied at the most upstream manhole represented in the model. If additional infrastructure is being added upstream, the grouping of loading data will need to be updated to ensure flows are properly allocated.

6.0 CAPACITY ASSESSMENT

6.1 DESIGN CRITERIA

After building the hydraulic model, as outlined in Section 5.0, planning data as outlined in the previous section was used in combination with a variety of design criteria to determine sewage flows for existing and future scenarios. An overview of the criteria for the flow input data for dry and wet weather flow conditions for current and future model scenarios is summarized in Table 6-1. Refer to Tech Memo 6 in Volume 2, Appendix J and Tech Memo 7 in Volume 2, Appendix K for additional information.

Table 6-1: Overview of Dry and Wet Weather Flow Inputs for Existing and Future Model Scenarios

Design Parameters	Dry Weather Flow Analysis	Wet Weather Flow Analysis
Average Per Capita Rate Sewage Flow	Current Conditions: Sewage generation rates ranged from 110 to 312 L/cap/day for both residential and ICI growth. These rates were determined using population data and flow monitoring for each subcatchment.	
	Future Growth: 350 L/cap/day for both residential and ICI growth, as per the Design Guidelines and Supplemental Specifications for Municipal Services (DGSSMS).	
Peak Factor	Current Conditions: Diurnal patterns were derived from the flow monitoring data for weekdays and weekends to capture differences in sewage generation trends. In areas where no flow monitoring coverage existed, data from areas with similar land use characteristics were applied.	
	Future Growth: Diurnal patterns applied from model calibration (Current Conditions) based on the sewershed receiving flows from the proposed development.	
Dry Weather Groundwater Infiltration[1]	Current Conditions: Derived from flow monitoring data using the empirical Stevens-Schutzbach method for each monitored sewershed.	
	Future Growth: Greenfield Development: Allowance of 0.15 L/s/ha. Infill and Intensification: Sewershed specific based on model calibration and the sewers receiving flow from proposed development.	

Design Parameters	Dry Weather Flow Analysis	Wet Weather Flow Analysis
External Flows[2]	Current Conditions: Flows external to the city boundaries which are handled by the sanitary collection system were established based on flow monitoring, pumping station design, and agreements between the contributor and the City.	
	Future Growth: Growth of external flows was determined on a case-by-case basis from reviewing projected growth and staging of contributing areas through consultation with contributing area authorities. Large User flows were also separated as individual point loads in the future model scenarios to evaluate the impact on the localized collection system.	
Design Storm[3]	N/A	All Scenarios: 10-yr, 3 hour Chicago Distribution design storm for this study; 25-yr, 3 hour Chicago event was reviewed as a stress-test on the system.
Wet Weather Infiltration	N/A	Current Conditions: Developed based on widely accepted RTK unit hydrograph method using flow monitoring data.
	N/A	Future Development: Sewershed specific RTK parameters based on model calibration and the sewers receiving flow from proposed development.[4]

Note 1: Groundwater infiltration represents the assumed constant non-sewage contribution in the system resulting from groundwater leakage at joints, broken pipes, etc.

Note 2: Flows external to the city boundaries which are handled by the sanitary collection system include: The City of Kitchener Bridgeport and Falconridge SPS, Township of Woolwich Stockyards Industrial/Commercial Area and King 86 Power Centre Area; and Waterloo Region's Emergency Services Training & Research Complex (WRESTRC) and landfill leachate collection system. Large User flows identified which have the potential to significantly impact localized flows include the Region of Waterloo purge well (W14) in Uptown Waterloo and Kraus Flooring.

Note 3: A standard design storm is not currently specified by the City for the purposes of sanitary system capacity assessment. Best practices based on the state of industry standards were reviewed, including what was used in the 2002 Master Plan. The 3 hour Chicago storm events were subsequently reviewed to provide more conservative results and allow a degree of comparison to the historic work completed for the 2002 Master Plan.

Note 4: In the near-term, the impact of wet weather from new development should not be as excessive as that observed in monitored existing systems, since private-side stormwater/groundwater plumbing is per the Ontario Building Code, which forbids such connections to the municipal sanitary system. Additionally, new construction should reflect good construction practices for installation and water-tight seals if proper inspection practices are observed. Therefore, the application of the calibrated RTK parameters to new areas is considered conservative.

6.2 TARGET LEVEL OF SERVICE

The level of service is based on the capacity in the collection system and the risk of surcharging that would result in basement flooding. Table 6-2 summarizes the criteria for dry and wet weather flow analyses.

Table 6-2: Target Level of Service Criteria for Dry and Wet Weather Flow Analyses

Criteria	Dry Weather Flow Analysis	Wet Weather Flow Analysis
Target Level of Service	All scenarios: Ratio of maximum depth versus full depth (d/D) < 0.8	All scenarios: Ratio of maximum depth versus full depth (d/D) greater than 1 is considered acceptable provided the water level remains at least 1.8 m below ground elevation.

For DWF analysis, the ratio of maximum depth versus full depth (d/D) of the sewer shall be used to identify capacity constraints, as it is more representative of system capacity for a dynamic model. Based on industry best practices, any sewers with a d/D equal to or greater than 0.8 (80%) shall be identified as having capacity constraints. For WWF events, surcharging (d/D of greater than 1) is considered acceptable provided the water level remains at least 1.8 m below ground elevation. A water level of 1.8 m below ground elevation coincides with the assumed basement elevation for homes with direct or indirect basement connections to the sewer. Figure 6-1 illustrates the targeted level-of-service for WWF events in relation to the water elevation and typical basement elevations.

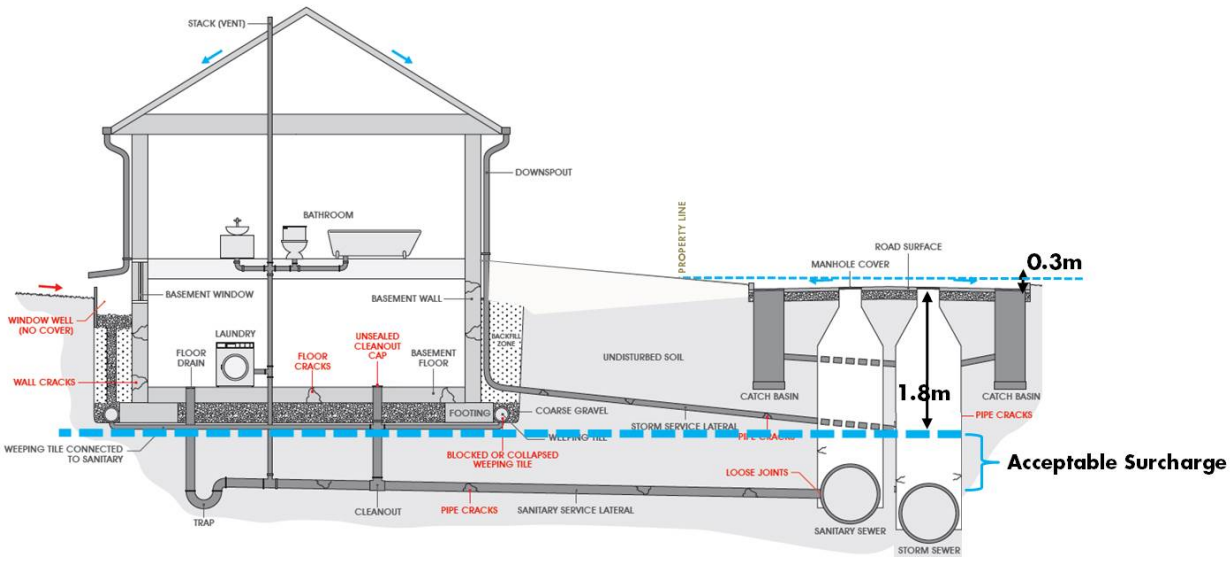
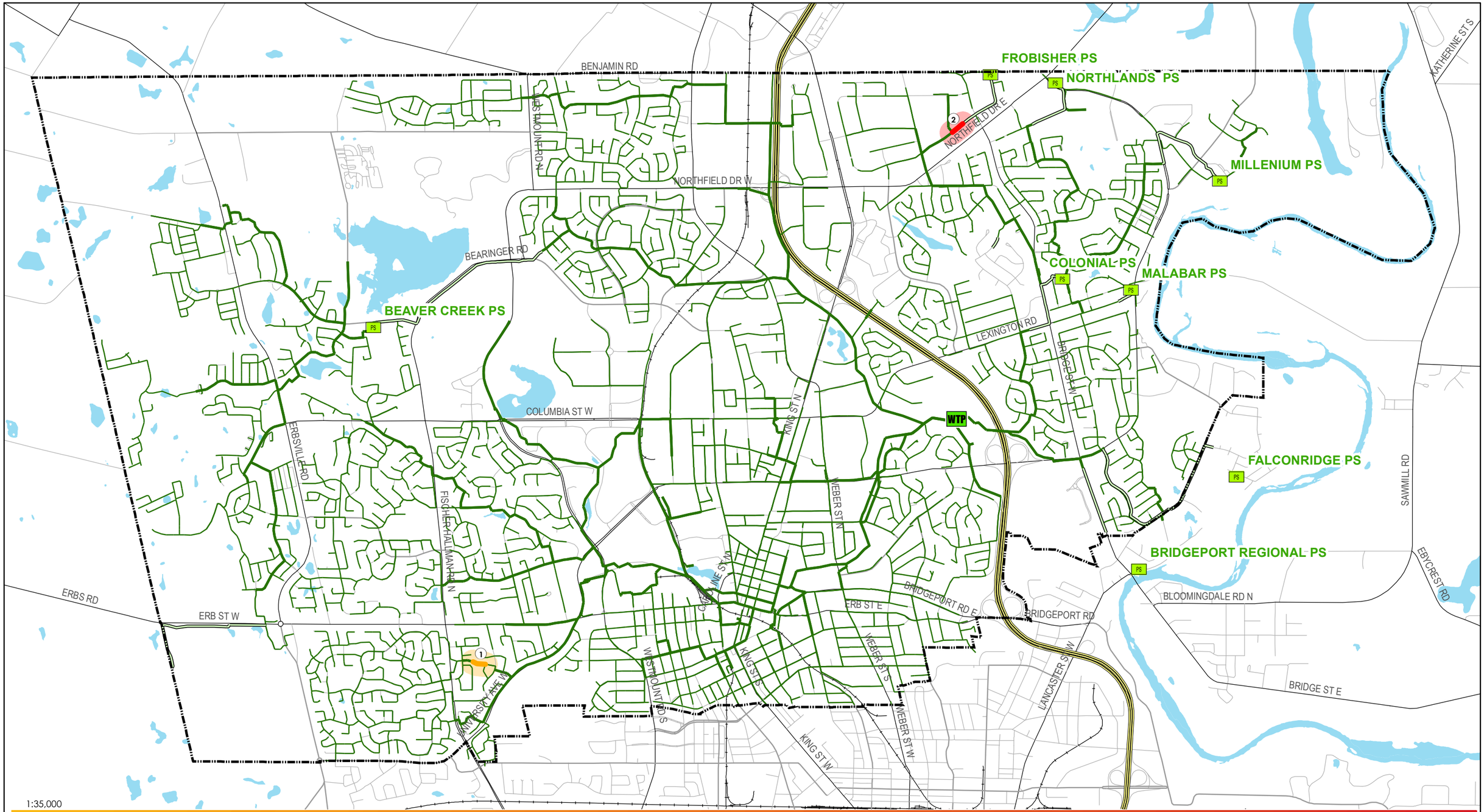


Figure 6-1: Definition of Flooding in Separated Sewer Systems

6.3 EXISTING CONDITIONS

The calibrated hydraulic model was used to evaluate the performance of the existing sanitary network. Two capacity constraints were identified under the existing conditions. The sewers immediately downstream of the Frobisher PS show a capacity constraint under both dry weather and wet weather conditions. In addition, a section of sewer within the maple trunk shows a capacity constraint under wet weather conditions. The locations of these two (2) capacity constraints are identified in Figure 6-2.



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Legend

- PS — Sewage Pump Station
- Forcemain
- WTP — Wastewater Treatment Plant

Sanitary Sewers

- Local Sewer
- Trunk Sewer

Existing Constraints

- Dry Weather Constraint
- Wet Weather Constraint

	Constraint	Details
1	Maple Hill Trunk	Existing conditions wet weather flow constraint
2	Downstream of Frobisher SPS	Existing conditions dry weather flow and wet weather flow constraint

Figure No. FIGURE 6-2

Title **EXISTING CONDITIONS CAPACITY CONSTRAINTS**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE

6.4 FUTURE SERVICING REQUIREMENTS

6.4.1 Existing Private Services

The majority of the City is currently serviced through municipal infrastructure; however, there are some areas that currently have private sanitary services. Through coordination with the City, 359 properties were identified as having private services. Although there is no requirement to provide municipal servicing to these properties at this time, servicing strategies have been developed in an effort to promote private septic system removal.

6.4.2 Capacity Constraints

The calibrated hydraulic model was used to evaluate the ability for existing infrastructure to accommodate proposed growth as discussed in Section 4.1. The following constraints have been identified based on the modeling results for future growth scenarios:

- The Maple Hill Trunk
- The Downstream of Frobisher PS
- The Lower Forwell Trunk

Under dry weather conditions, one capacity constraint is identified downstream of Frobisher SPS. This constraint was identified in the existing conditions scenario, and carried through all future scenarios.

Under wet weather conditions, three capacity constraints have been identified, including downstream of Frobisher SPS, a section of Maple Hill Trunk, and the Lower Forwell Trunk. The capacity constraint identified downstream of Frobisher SPS was identified under DWF conditions; therefore it is expected to also be a constraint under WWF conditions. The capacity constraint is identified in the Maple Hill Trunk was identified under the existing conditions, and carries through each of the future scenarios. The capacity constraint identified along the Lower Forwell Trunk is only identified in the 2029 modeling scenario under WWF conditions.

6.4.3 Greenfield Development

As discussed in Section 4.0, various Greenfield development areas have been identified which are expected to be developed within the 2031 planning horizon. The hydraulic model was used to confirm system capacity to accommodate these developments; any required infrastructure upgrades will be addressed in Section 7.0. In addition to ensuring capacity within the system, servicing strategies will also be provided which will include extension of existing services and connections to existing infrastructure.

6.5 FUTURE SERVICING STRATEGIES

The following subsections outline the potential servicing strategies proposed to address the future servicing requirements, as outlined in Section 6.4.

6.5.1 Servicing for Existing Private Services

Properties currently provided with private sanitary servicing were reviewed to evaluate the feasibility of providing municipal servicing. A total of 359 properties have been identified which are currently not connected to municipal sanitary servicing and are serviced privately by septic systems. These parcels have been grouped into 31 areas based on serviceability; refer to Figure 6-3.

The properties were grouped into three (3) categories based on land use type and proximity to Wellhead Protection Sensitivity Areas. Refer to Figure 6-4 for additional details:

1. The first category includes the Wellhead Protection Sensitivity Area 8, which delineates the area outside of the *10 year time of travel* to the limit of the total land area contributing water to a municipal drinking-water. This group includes the following land uses: consisting of agricultural, recreational/commercial, institutional, and residential land use.

2. The second category includes properties which are outside of the Wellhead Protection Areas. This group includes the following land-uses: consisting of agricultural, recreational/ commercial, institutional, and residential land use.

3. The third category has been assigned to Industrial/Commercial properties because the waste generation for these types of properties can range dramatically in quantity and quality from site to site.

Each category will be evaluated as a distinct alternative for A) remaining privately serviced ("Do Nothing") and B) providing municipal servicing. Refer to Table 6-3.

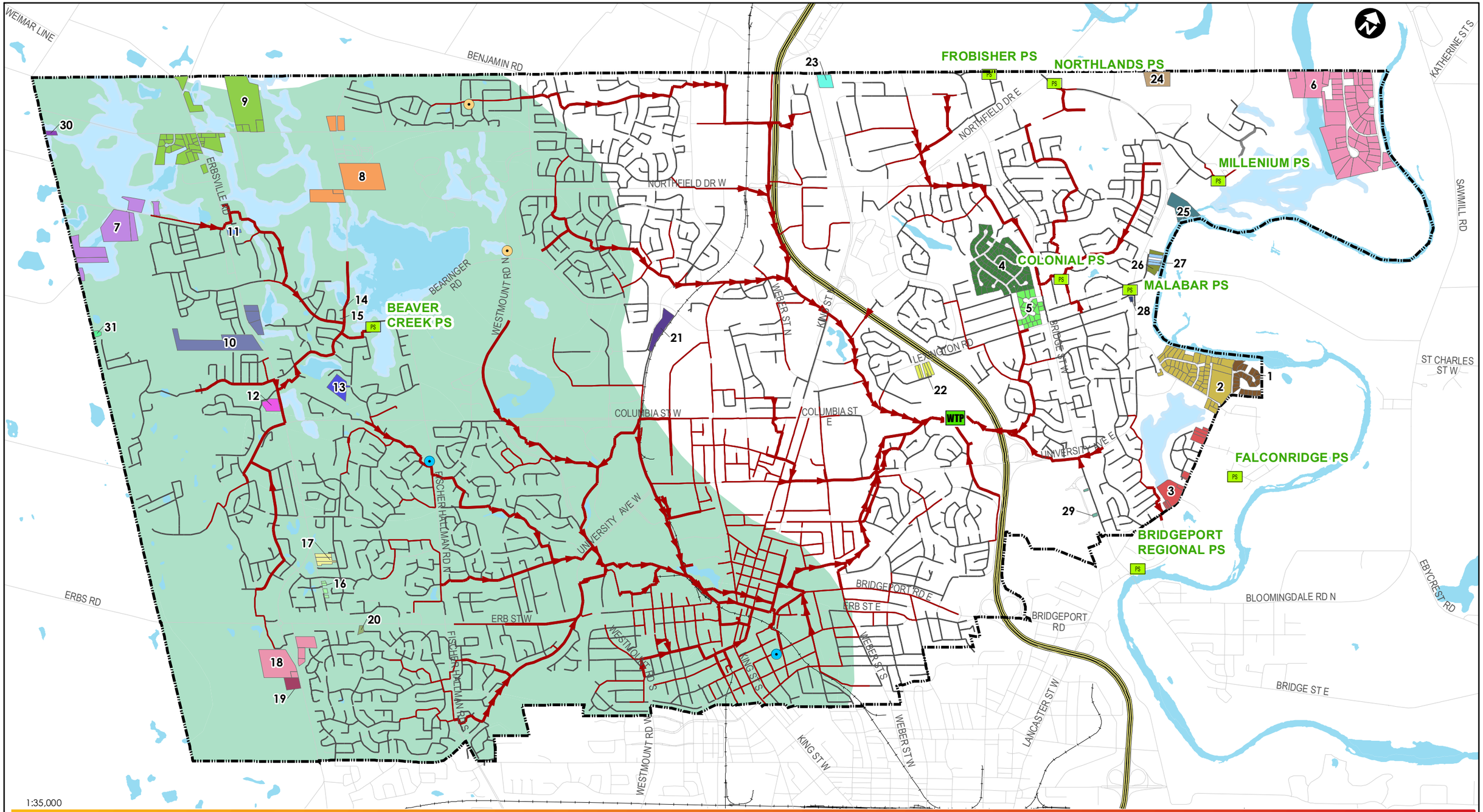
Sewage loadings have been developed for each property, and a model simulation has been developed to evaluate the impact of providing municipal servicing to existing private services. Based on this preliminary analysis, additional capacity constraints have been identified along the Forwell Trunk, and downstream of Frobisher SPS. These locations have already been identified as having capacity constraints based on the growth scenarios, but the capacity constraints are more significant when flows from the properties on septic are included.

Table 6-3: Servicing Alternatives for Existing Private Services

Category Description		Alternatives		Required Upgrades
1	Properties within Wellhead Protection Sensitivity Areas (16 parcel groups)	A	Do Nothing	No Upgrades Required
		B	Provide Municipal Servicing	Upgrades along the Lower Forwell Trunk
2	Properties Outside Wellhead Protection Sensitivity Areas (14 parcel groups)	A	Do Nothing	No Upgrades Required
		B	Provide Municipal Servicing	Upgrades to receiving sewers of Frobisher SPS
3	Industrial and Commercial Properties (1 parcel group)	A	Do Nothing	No Upgrades Required
		B	Provide Municipal Servicing	No Upgrades Required

Municipal servicing could be provided to the majority of these parcels through an extension of local sewers and conveying flows by gravity. However some properties cannot be serviced by gravity and will require a pump station or grinder pump. A summary of the servicing strategies are listed in Table 6-4.

It can be noted that several properties on private sanitary services are located in the Beaver Creek development area. As part of the extension of municipal services to accommodate proposed development, upgrades could be coordinated to provide municipal servicing to existing residents at the same time.



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Legend

- PS — Existing Pump Station
- WTP — Wastewater Treatment Plant
- Existing Properties on Private Services

All Sanitary Sewers
- Local Sewer
- Trunk Sewer

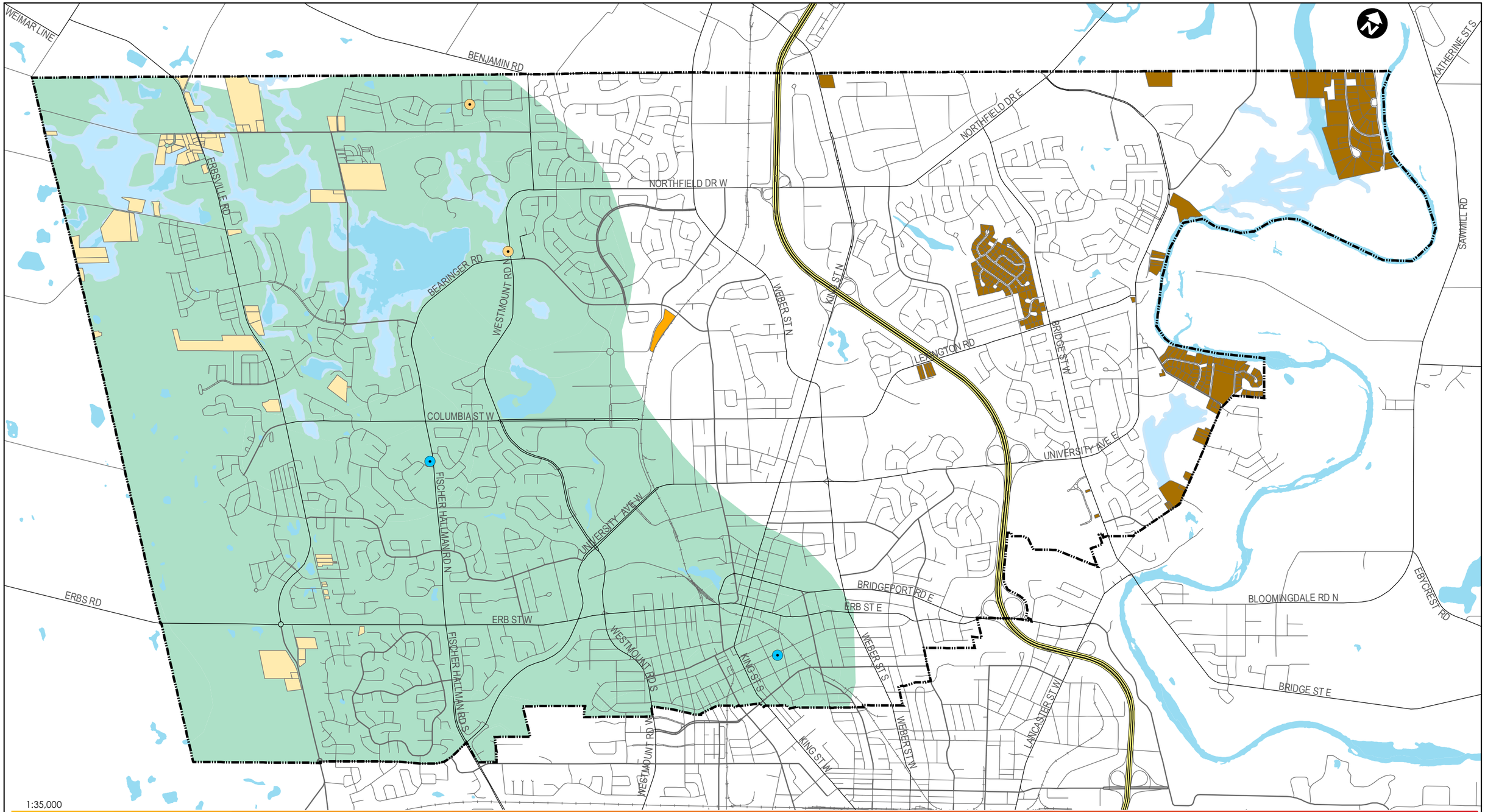
Model Selection Set
- Local Sewer
- Trunk Sewer

Drinking Water Wells
- Well
- Test Well
- Wellhead Protection Area 8
- Wetland

Figure No. FIGURE 6-3

Title **CURRENT PROPERTIES SERVICED BY SEPTIC SYSTEMS (GROUPED BY SERVICEABILITY)**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE



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Legend

Septic Properties
- Category 1
- Category 2
- Category 3

Drinking Water Wells
- Well
- Test Well

- Wellhead Protection Area 8
- Wetland

Figure No. FIGURE 6-4

Title **CURRENT PROPERTIES SERVICED BY SEPTIC SYSTEMS (CATEGORIES)**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE

Table 6-4: Individual Parcel Review

Grouping	Description	Servicing Strategy
Category 1: Properties inside Wellhead Protection Areas		
7	Beaver Creek - Wideman	Not serviceable by gravity, therefore an SPS would be required. This parcel group is within Environmentally Sensitive Area, therefore this area will not be developed further, and municipal servicing is not recommended at this time.
8	Beaver Creek (1)	Servicing to this area will require an SPS and forcemain. Due to proposed development in this area, servicing to this area is currently in design. Therefore it is recommended municipal servicing be provided to these properties only once the required infrastructure is in place.
9	Beaver Creek (2)	Servicing to this area will require an SPS and forcemain. Due to proposed development in this area, servicing to this area is currently in design. Therefore it is recommended municipal servicing be provided to these properties only once the required infrastructure is in place.
10	Erbsville Rd at Laurelwood Dr	This parcel group can be serviced by gravity to the local sewer at White Elm Blvd and Erbsville Rd.
11	Wideman Rd at Erbsville Rd	This parcel can be serviced by gravity. Extend existing service along Werni Crt.
12	Erbsville Rd, north of Columbia Street W	This parcel can be serviced by gravity to adjacent trunk sewer along Erbsville Road.
13	Brentcliffe Drive	This parcel can be serviced by gravity with a sewer extension along Brentcliffe Drive.
14	Beaver Creek Rd	This parcel can be serviced by gravity to the adjacent trunk sewer along Beaver Creek Rd.
15	Beaver Creek Rd	This parcel can be serviced by gravity to the adjacent trunk sewer along Beaver Creek Rd.
16	Erbsville Crt	This parcel group can be serviced by gravity to the local sewer along Erbsville Crt.
17	Erbsville Road	This parcel group can be serviced by gravity by constructing a sewer along Erbsville Crt.
18	Erbsville Road	This parcel group can be serviced by gravity to the local sewer along Erbsville Road.
19	Erbsville Road	This parcel is not serviceable by gravity with the existing sewers. Therefore a grinder pump will be required.
20	Heather Hill	This parcel is serviceable by existing gravity along Heather Hill.

Grouping	Description	Servicing Strategy
30	Conservation Drive	This property could be serviced upstream of Beaver Creek SPS with a gravity Trunk.
31	Autumn Willow Drive	This property could be serviced upstream of Beaver Creek SPS by connecting to the existing sewer along Autumn Willow Drive.
Category 2: Properties outside of Wellhead Protection Areas		
1	Bridgeport/Falconridge - River Oak	Due to elevation, this area cannot be serviced by gravity. Either a sewage pumping station or a low pressure system with grinder pumps would be required to service this area due to elevations. The flows from these properties would be directed into Falconridge SPS in the City of Kitchener.
2	Bridgeport/Falconridge - Woolwich St N	This area is serviceable by gravity to Falconridge SPS in the City of Kitchener along Hawkswood Drive. A trunk main extension would be required and local sewers through the subdivision.
3	Bridgeport/Falconridge	These parcels may be serviced by gravity to Falconridge PS via City of Kitchener sewers along Hawkswood Drive. These properties could not be serviced by the nearest gravity main draining to Bridgeport due to elevation restrictions.
4	Colonial Acres (1)	This area could be serviced by gravity to Lee Ave and Castlefield Drive (SW corner). Minimum cover of 2 meters is just achieved, therefore a further feasibility study should be conducted, and a Lift Station, or low pressure system with grinder pumps may be required.
5	Colonial Acres (2)	This section is serviceable to Wissler Rd, upstream of the Colonial PS.
6	Country Squire (1)	This area was not included in the ultimate build-out that Millennium SPS was designed for. Therefore Millennium SPS would not have the capacity to accept these flows, and a forcemain would be required to direct flows to Colonial SPS, or trunk upgrades would be required. Due to the required infrastructure upgrades, it is recommended that servicing be scheduled beyond the 2031 planning horizon.
22	Lexington Ct	This parcel group can be serviced by gravity to the existing sewer along Lexington, or along Dearborn Pl.
23	King St at Bridge St	This parcel can be serviced by gravity to the trunk along Northland Rd.
24	County Squire (2)	This parcel can be serviced by gravity to the existing sewers along University Ave East. Flows can be diverted upstream of Millennium SPS.

Grouping	Description	Servicing Strategy
25	Grand Bluffs at Eastbridge	This parcel cannot be serviced by gravity. Flows could be directed to Millennium PS using a grinder pump.
26	Woolwich Place (1)	This parcel group may require grinder pumps, as elevations do not permit gravity connections.
27	Woolwich Place (2)	This parcel group can be serviced to existing sewer adjacent to property. Flows may be directed to Malabar SPS.
28	Malabar Dr at Lexington Rd	This parcel can be connected to existing sewer in front of property, connection by gravity, upstream of Malabar SPS.
29	Bridgeport St near Bridal Trail	This parcel group can be serviced by the existing gravity main adjacent to property. This will drain into Bridgeport SPS.
Category 3: Industrial/Commercial Properties		
21	University of Waterloo R&T Park	This parcel can be serviced by the existing local gravity sewer along Wes Gram Way and the Laurel Trail.

6.5.2 Capacity Constraints

Evaluating the capacity of existing infrastructure to accommodate proposed growth was completed using the hydraulic model. The identified constraints have been identified in Figure 6-5 and are listed below:

4. Maple Hill Trunk
5. Downstream of Frobisher PS
6. Lower Forwell Trunk

A drawing review was conducted at the location of each constraint to allow utility conflicts to be avoided during the development of servicing alternatives. The Procedure F-6-1 published by the MOECC in 2014 requires that watermain are to be aligned with a minimum horizontal separation from sanitary sewers of 2.5 m. Alternative solutions for addressing the identified capacity constraints are presented in the following sections.

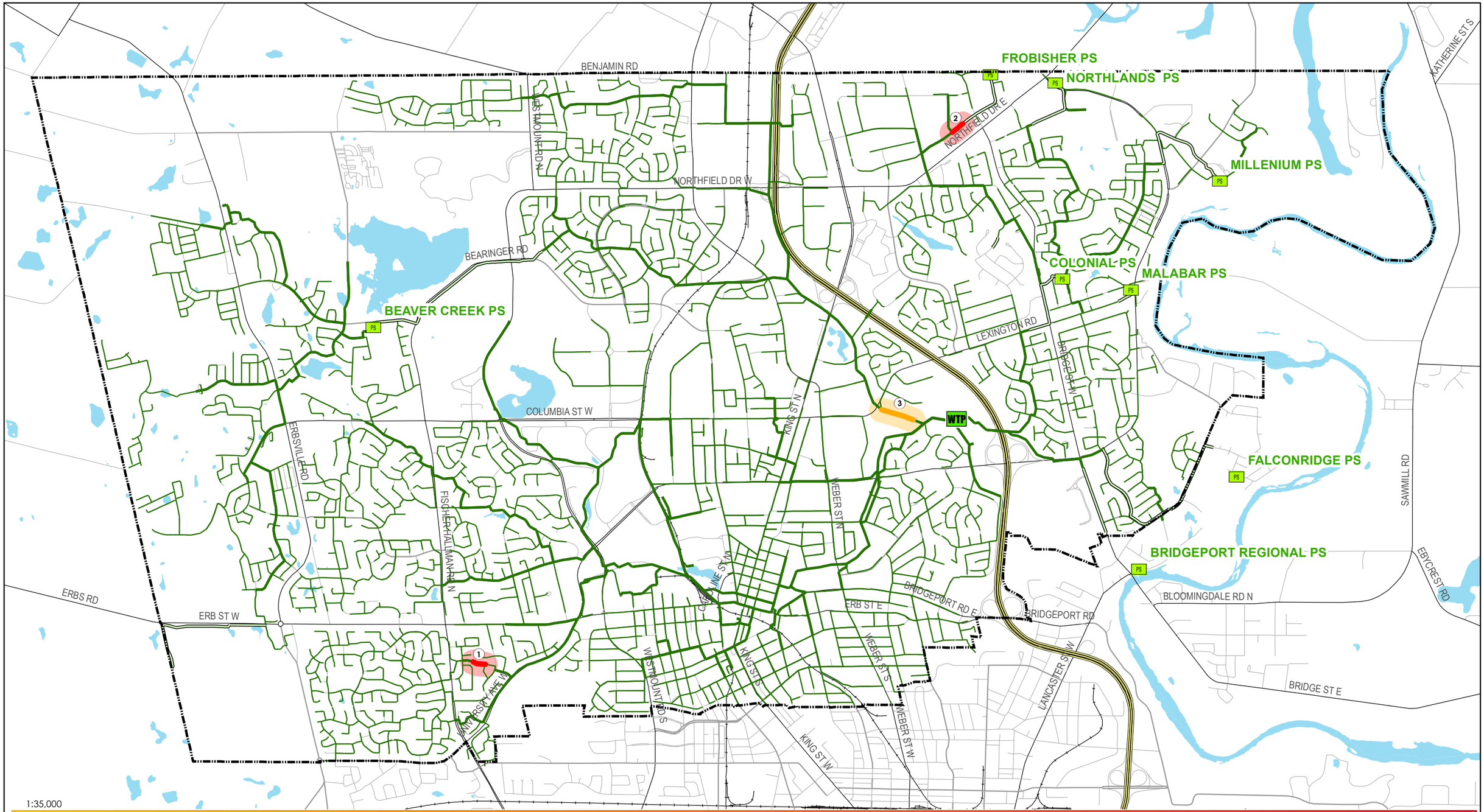
6.5.2.1 Maple Hill Trunk

Capacity constraints have been identified for Maple Hill Trunk under existing and future model conditions, and as such alternatives have been generated to address this constraint. During the drawing review of the Maple Hill Trunk at the location of the capacity constraint, discrepancies were identified between the construction drawings and the model geodatabase. The discrepancies included the inverts of the two (2) sewer pipes upstream of the capacity

constraint. During the initial geodatabase verification phase, a drawing review was not warranted in this area, and therefore this discrepancy was not identified at that time.

The location of the capacity constraint along the Maple Hill Trunk is in an existing easement. Therefore, the 'Do Nothing' alternative may be a viable solution if there are no service connections within this area, and the risk of basement flooding is low. The easement is 6 m (20 ft) wide. Due to the alignment of the existing sanitary sewer, there is limited space available within the existing easement for twinning on either side of the existing sewer. The sewers at the location of the capacity constraint could be replaced along the existing alignment to improve hydraulic capacity through the sewer section. Upgrades to this section which would improve the hydraulic capacity could include increasing the size of pipe, or the slope of the pipe. A fourth alternative would be to adjust the operation of the upstream weir (overflow structure) to divert flows along an alternate route and potentially utilize available capacity.

The alternatives for addressing the capacity constraint in the Maple Hill Trunk are summarized in Table 6-5.



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Legend

- PS — Sewage Pump Station
- Forcemain
- WTP — Wastewater Treatment Plant

Sanitary Sewers

- Local Sewers
- Trunk Sewers

Capacity Constraints

- Existing Conditions Constraint
- 2029 WWF Constraint

	Constraint	Details
1	Maple Hill Trunk	Existing conditions wet weather flow constraint
2	Downstream of Frobisher SPS	Existing conditions dry weather flow and wet weather flow constraint
3	Lower Forwell Trunk	2029 wet weather flow constraint

Figure No. FIGURE 6-5

Title **CAPACITY CONSTRAINTS EXISTING & FUTURE CONDITIONS**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE

Table 6-5: Maple Hill Trunk Alternatives to Address Capacity Constraints

Description		Alternatives	
4	Maple Hill Trunk Capacity	A	Do Nothing
		B	Twin Sewers at Location of Capacity Constraint
		C	Upsize or Steepen Sewers at Location of Capacity Constraint
		D	Divert Flow

6.5.2.2 Downstream of Frobisher SPS

Capacity constraints have been identified downstream of the Frobisher SPS under existing and future model conditions, and as such alternatives were generated to address this constraint. Follow-up has been recommended to confirm the pump curves at this station as the downstream constraint is related to the operating capacity of the Frobisher pump being greater than the capacity of the sewers.

A drawing review was conducted to avoid potential utility conflicts. Given the available separation from nearby utilities, the hydraulic capacity through this section of sewer could be increased by twinning the existing sewer. Alternatively, the hydraulic capacity could be increased by replacing the sewers along the existing alignment. Upgrades to this section which would improve the hydraulic capacity could include increasing the size of pipe, or the slope of the pipe. This alternative would require bypass pumping.

The alternatives for addressing the capacity constraint downstream of Frobisher SPS are summarized in Table 6-6.

Table 6-6: Downstream of Frobisher SPS Alternatives to Address Capacity Constraints

Description		Alternatives	
5	Downstream of Frobisher SPS Capacity	A	Do Nothing
		B	Twin Sewer at Location of Capacity Constraint
		C	Upsize or Steepen Sewers at Location of Capacity Constraint

6.5.2.3 Lower Forwell Trunk

A capacity constraint has been identified along the Lower Forwell Trunk. This capacity constraint is caused by the population growth identified in Section 4.2, but additional stress is observed in this location when properties currently on septic systems are connected to the sanitary network.

Therefore, this area is identified as a capacity constraint, and alternatives have been identified below.

The alternatives for addressing the capacity constraint along the Lower Forwell Trunk are summarized in Table 6-7. This upgrade would only be triggered in the event that the municipal servicing is provided to the existing properties on private services, specifically the properties in Category 1 (within Wellhead Protection Sensitivity Areas), as many of these properties are upstream of the Lower Forwell Trunk.

Table 6-7: Lower Forwell Trunk Alternatives to Address Capacity Constraints

Description		Alternatives	
6	Lower Forwell Trunk	A	Do Nothing
		B	Twin Sewer at Location of Capacity Constraint
		C	Upsize or Steepen Sewers at Location of Capacity Constraint

6.5.3 Greenfield Servicing

As described in Section 4.0, development is anticipated in various Greenfield areas within the 2031 planning horizon. Population growth associated with this development was incorporated in the modelled future growth scenarios, and therefore any capacity constraint within the existing infrastructure is identified in Section 6.4.2. In addition to ensuring capacity within the system, servicing strategies have been developed for each area; these servicing strategies are summarized in Table 6-8 below.

A map of the Greenfield areas is provided in Figure 4-1 and parcel information and servicing strategies are provided in Table 5-1 for the parcels identified in the *Staging and Development Report* and for the additional Designated Greenfield areas identified in the *City-Wide Growth Forecast*.

The year of completion was estimated for each Parcel Group, which aided in development of the population distribution used for the modeling activities. The year of completion for Parcel ID #1 to #39 were developed based on the timing described in the Staging and Development Report (Parcel ID #1 to #39). A review of current site conditions was completed to determine the current status of the property, and the anticipated year of completion was revised accordingly. Additional Greenfield areas (Parcel ID #40 to #61) were provided in the *City-Wide Growth Forecast* which were used to allocate the populations for the 2029 scenario only, these properties were assumed to be completed in the year 2029.

Additional information has been provided by the City indicating revised timing for the Parcel Groups following the completion of the modeling activities. Some areas as identified in Table 6-8 have developed more quickly than originally expected. It should be noted that the 2029 scenario included full build-out. This change provides the potential for sanitary sewer constraints to present themselves in earlier planning horizons within these isolated areas; however, based on the constraints identified in the 2029 planning scenario and their proximity to the Greenfield Development Areas this was not considered to be of concern. Therefore, no updates were made to the allocation of planning data in the hydraulic model based on the revised timing.

6.6 EVALUATION OF ALTERNATIVES

Each servicing alternative described in the preceding section have been evaluated based on the evaluation method described in Section 3.4. The evaluation criteria were developed to address natural, social, and economic impacts. The results of the evaluation are provided in the following sections for each alternative, and additional details regarding the scoring can be found in the Appendix C.

6.6.1 Municipal Servicing of Private Connections

The results of the evaluation of alternatives identified in Section 6.4 are presented in Table 6-9 on the following page. The results of the evaluation indicate that it would be beneficial to transfer all existing privately serviced sites to municipal servicing. The priorities for providing municipal servicing are based on the results of the ranking and are provided below:

1. Category 3: Industrial/Commercial Properties
2. Category 1: Properties Within Wellhead Protection Areas
3. Category 2: Properties Outside Wellhead Protection Areas

Table 6-10 provides an individual parcel review outlining the servicing recommendations based on the categorical priority ranking. Refer to Figure 6-1 for spatial reference.

Table 6-8: Servicing Strategies for Greenfield Development Areas

Parcel ID	Location		Description of Development Parcel Sanitary Servicing	Year Expected to be Completed
	Street Address	Development Name		
1	Wideman Road	Owen	Sanitary services to be extended from the existing residential subdivision to the east.	2019 [1]
2	450 Wilmot Line & 500 Wilmot Line	Vista Hills	Sanitary services to be via the Cedar Trunk 2 extension, which was installed between 2007 and 2013.	2024 [1]
3	340 Wilmot Line	Clair Creek Meadows	Sanitary services to be extended from 30T-97024 (Parcel ID 2) to the north.	2024
4	250 Wilmot Line	Greyerbiehl	Southern portion of the property to receive sanitary services from the Clair Hills subdivision to the east (extension of sewer at intersection of Columbia St. and St Moritz). Northern portion of the property to receive sanitary services from 30T-05403 (Parcel ID 3) to the north.	2024
5	672 Trillium Estates Ltd	Trillium Area 7	Sanitary services to be extended northward on Erbsville Road.	2019
6	Laurelwood Drive	Trillium - Laurelwood	Servicing via an existing 200 mm sanitary sewer on Laurelwood Drive.	2024
7	460 Columbia	Trillium - Columbia	No sanitary sewer on Columbia Street, however, road reconstruction is planned for Columbia St in 2014/2015.	2029
8	76, 86, 90 Erbsville Court & 70 Erbsville Court	Lederer Et. Al/ Vanden Berg	Sanitary servicing to be extended from existing 200 mm sanitary sewers on Paradise Crescent and Beechwood Drive.	2024
9	Bamberg Crescent	Clair Hills	Sanitary servicing to development available.	2014 [1]
10	Montpellier Street	Montpellier	Sanitary servicing to development available.	2014
11	745 University Avenue East	Kauffman Estates	Sanitary servicing to development available.	2019
12	Wismer Street and Woolwich Street	Triple Crown Estates	Sanitary services to be extended westward on Woolwich Street from Falconridge Drive. Temporary pumping station permissions granted.	2029
13	Woolwich Street	Woolwich Estates	Sanitary services to be extended to convey flow to the Melitzer Creek Pumping Station in Kitchener.	2024
14	Fischer-Hallman Road	UW North Campus	Subject to a memorandum of understanding between the City of Waterloo and the University of Waterloo for grading, road works and installation of services (storm, sanitary, water, utilities).	2024
15	Woolwich Street	Galantai	Sanitary services to be extended westward on Woolwich Street from Falconridge Drive.	2029
16	435 Winchester Drive	Winchester	Serviced via a 200 mm sanitary sewer on Winchester Drive.	2014
17	250 The Wilmot Line	Greyerbiehl (South)	Southern portion of the property to receive sanitary services from the Clair Hills subdivision to the east (extension of sewer at intersection of Columbia St. and St. Moritz).	2024
18	Block 37	Carriage Cross (Blk 37)	Sanitary services to be extended as part of the servicing of subdivision 30T-08401.	2029
19	Block 38	Carriage Cross (Blk 38)	Sanitary services to be extended as part of the servicing of subdivision 30T-08401.	2029
20	110 Erb Street West	The Barrelyards	Sanitary servicing to development available.	2019
21	515 Erbsville Road	Howald	Sanitary servicing to development available.	2024
22	449 Brentcliffe Drive	Auerbach	Sanitary servicing to development available.	2029
23	480 Wilmot Line	Karges	Sanitary services to be extended from 30T-97024 (Parcel ID 2).	2024
24	290 & 294 Bridge Street West	Allenby Court	Sanitary servicing to development available.	2019
25		West Side Employment Lands (North)	Sanitary servicing to be extended from the employment/commercial lands to the south (Parcel ID 26)	2029
26	930 Erb Street West	West Side Employment Lands (South)	Sanitary servicing to be extended from the west.	2029
27	2001 University Avenue East	Rural East (City)	Extend 200 mm sanitary sewer on University Avenue.	2029

Parcel ID	Location		Description of Development Parcel Sanitary Servicing	Year Expected to be Completed
	Street Address	Development Name		
28	Conservation Drive/ Roy Schmidt Road	Activa (Conservation)	Services to be extended from Beaver Creek Road when available.	2024
29	720 Erbsville Road	Simpson	Sanitary services to be extended northward on Erbsville Road.	2029
30	665 Erbsville Road	Michaels	Sanitary services to be extended northward on Erbsville Road.	2029
31	576 Conservation Drive	Eperjesi	Sanitary services to be extended northward on Beaver Creek Road.	2029
32	556 & 560 Conservation Drive	Cook Homes (Conservation)	Sanitary services to be extended northward on Beaver Creek Road.	2029
33	Southwest corner of Beaver Creek Road	Groff (Conservation - 1)	Sanitary services to be extended northward on Beaver Creek Road.	2029
34	and Conservation Drive	Groff (Conservation - 2)	Sanitary services to be extended through adjacent lands.	2029
35	624 Conservation Drive	Brohman	Sanitary services to be extended westward on Conservation Drive.	2029
36	675 Conservation Drive	Go Cart	Sanitary services to be extended westward on Conservation Drive.	2029
37	Northeast corner of Conservation/ Erbsville	Hexagon	Sanitary alignment to the lands to be determined through a servicing analysis.	2029
38	795 Erbsville Road	Activa (Erbsville)	Sanitary to be extended by developer from Conservation Drive.	2029
39	1021 Bisch Street	Zister	Sanitary to be extended by developer from Conservation Drive.	2029
40	East of University Ave, South of Wismer Street, West of Pelham Street		These properties may be services to Falconridge SPS in the City of Kitchener.	2029
41	Maverick Street		Properties are to be serviced by the existing sewers adjacent to the properties, flows will drain into to the Falconridge SPS in the City of Kitchener.	2029
42	University Avenue East at Wismer Street		Property to be services by the existing sewer along University Ave East, flows will drain into to the Falconridge SPS in the City of Kitchener	2029
43	University Ave East at New Bedford Drive		Properties are to be serviced by the existing sewers adjacent to the properties. Flows will drain into the Eastbridge catchment area, upstream of the Colonial SPS.	2029
44	Grey Silo Rd		Sanitary services to be extended along Grey Silo Road, flows will drain into Millenium SPS.	2029
45	Grey Silo Rd		A grinder pump is required to service the property. Flows to be directed to Millenium SPS.	2029
46	Grey Silo Rd		Sanitary Services to be extended north from Grey Silo Road. Flows will drain into the Eastbridge catchment area, upstream of the Colonial SPS.	2029
47	Paris Boulevard		Properties are to be serviced by the existing sewers adjacent to the properties. Flows will drain into the Cedar Trunk along Brandenburg Boulevard.	2029
48	Erb Street, West of Ira Needles		These properties are to be services by a trunk sewer required from Montpellier Drive, these flows will drain into the Lower Cedar Trunk.	2029
49	St. Moritz Avenue/ Interlaken Drive/ Atheim Crescent		Properties are to be serviced by the existing sewers adjacent to the properties. Flows will drain into the Middle-Cedar Trunk.	2029
50	Wideman Road/ Laurelwood Drive		Properties are to be serviced by the existing sewers adjacent to the properties. Sanitary sewers will connect to Meadowsweet Avenue and flows will drain into the Upper Cedar Trunk.	2029
51	Meadowsweet Avenue		Sanitary sewers will connect to Meadowsweet Avenue and flows will drain into the Upper Cedar Trunk.	2029
52	Conservation Drive		Property to be services by the existing services north from Conservation Drive, upon completion of servicing to the Beaver Creek Development Area.	2029
53	Conservation Drive		Property to be services by the existing services north from Conservation Drive, upon completion of servicing to the Beaver Creek Development Area.	2029

Parcel ID	Location		Description of Development Parcel Sanitary Servicing	Year Expected to be Completed
	Street Address	Development Name		
54	Conservation Drive		Property to be services by the existing services north from Conservation Drive, upon completion of servicing to the Beaver Creek Development Area.	2029
55	Pinery Trail/ Rideau River Street/ Wasaga Crescent		Development is underway, sanitary servicing will be connected to existing sewer adjacent to the properties, and flows will drain into the Upper Forwell Trunk.	2029
56	Beaver Creek Road and Conservation Drive		To be serviced along Beaver Creek Road once infrastructure is in place to service the Beaver Creek development area.	2029
57	Laurelwood Drive and Bearinger Road		To be serviced by existing services along Laurelwood Drive, flows will drain into Beaver Creek SPS.	2029
58	University of Waterloo North Campus		A grinder pump will be required for this property due to elevations. Sanitary servicing will be connected to the existing services southwest of the property, and flows will drain south along Westmount Road, and ultimately into the Laurel Trunk.	2029
59	Regal Place		Properties to be serviced by infrastructure adjacent to the properties along Regal Place. Flows will be directed south to the Upper Cedar Trunk, and will ultimately flow into the Beaver Creek SPS.	2029 [1]
60	Werni Court		Properties to be serviced by existing infrastructure adjacent to the properties. The flows will drain into the Upper Cedar Trunk via Cedar Bend Drive.	2029 [1]
61	Westvale (northwest corner)		Properties to be serviced by existing infrastructure adjacent to the properties. Flows will drain through the Westvale Area and ultimately into the Maple Trunk along University Avenue West.	2029

Note 1: The year of completion was estimated for each Parcel Group, which aided in development of the population distribution used for the modeling activities. Additional information has been provided by the City indicating revised timing for the Parcel Groups following the completion of the modeling activities. The development on the identified Parcel Groups have been completed.

Table 6-9: Results of Evaluation of Alternatives

Ranking

Good Neutral Poor

Ranking			Servicing Alternative					
			1. Within Wellhead Protection Areas		2. Outside Wellhead Protection Areas		3. Industrial/Commercial Properties	
			1A	1B	2A	2B	3A	3B
Category	**Criteria**	**Weight**	Do Nothing	Municipal Servicing	Do Nothing	Municipal Servicing	Do Nothing	Municipal Servicing
Technical	Hydraulic Improvements	1						
	Operations and Maintenance	1						
	System Resiliency	1						
Ease of Implementation	Constructability	1						
	Regulatory Considerations	1	-	-	-	-	-	-
Social	Impact for Surrounding Residents	1						
System Suitability	Consistency with Planned Upgrades	1						
	Consistency with Operating Strategies	1						
Environment/ Sustainability	Carbon Footprint	1						
	Impact on Terrestrial/ Aquatic Systems	1						
Financial	Capital Cost	1						
	Operating and Maintenance Cost	1						
Total Score			5 1/2	6	5 1/2	5 3/4	5 1/2	6 1/4

Table 6-10: Staging and Development Plan for Providing Municipal Servicing to Properties Currently with Private Servicing

Priority	Category	Year of Implementation
1	Category 3: Industrial/Commercial Properties	2019
2	Category 1: Properties within Wellhead Protection Areas: • Property Group 7 is in an ESA, therefore municipal servicing is not recommended. • Property Groups 8, 9, & 30 are recommended to be serviced with the North Beaver Creek development area, and municipal servicing is to be provided at once this infrastructure is installed.	2024 Not Recommended 2029 (Dependent on timing of Beaver Creek Infrastructure)
3	Category 2: Properties outside Wellhead Protection Areas: • Property Group 6 exceeds the capacity of Millennium SPS; therefore, extensive infrastructure upgrades would be required before servicing.	2029 Beyond 2029

6.6.1.1 Improving Maple Hill Trunk Capacity Constraint

The results of the evaluation of alternatives identified in Section 6.4.2 are presented in Table 6-11.

It can be seen from Table 6-11 that the top ranked alternative is 4D, divert flow along Westvale Drive/Fischer Hallman Road to the lower Maple Hill Trunk. This alternative allows residual capacity within the system to be utilized, the cost to reconfigure one manhole is expected to be less than the cost of twinning or replacing the length of pipe, this alternative does not require work within the narrow easement and therefore improves accessibility during construction.

Table 6-11: Results of Evaluation for Alternative 4

Ranking

Good Neutral Poor

Ranking		**Alternative**			
		Maple Hill Trunk Capacity			
		4A	4B	4C	4D
Category	**Criteria**	Do Nothing	Twin Sewer Section	Replace Sewer Section	Divert Flow
Technical	Hydraulic Improvements				
	Operations and Maintenance				
	System Resiliency				
Ease of Implementation	Constructability				
	Regulatory Considerations				
Social	Impact for Surrounding Residents				
System Suitability	Consistency with Planned Upgrades				
	Consistency with Operating Strategies				
Environment/ Sustainability	Carbon Footprint				
	Impact on Terrestrial/ Aquatic Systems				
Financial	Capital Cost				
	Operating and Maintenance Cost				
Total Score		6	6 3/4	7 1/4	8 1/4

6.6.1.2 Improving Downstream Frobisher SPS Capacity Constraint

The results of the evaluation of alternatives identified in Section 6.4.2 are presented in Table 6-12.

It can be seen from Table 6-12 that the top ranked alternative is Alternative 5C. This is because it reduces operations and maintenance due to the removal of old infrastructure, and reduced risk of utility conflicts due to unchanged alignment.

6.6.1.3 Improving Lower Forwell Capacity Constraint

The results of the evaluation of alternatives identified in Section 6.4.2 are presented in Table 6-13.

It can be seen from Table 6-13 that the top ranked alternative is Alternative 6A which is the 'do nothing' alternative. This constraint is located through the Hillside Trail, adjacent to the WWTP. It is unlikely that surcharging in this area would cause basement flooding because there are no direct connections. The Hillside Trail is an environmentally sensitive area, and the 'Do Nothing' alternative avoids construction through this area.

Table 6-12: Results of Evaluation for Alternative 5

Ranking

Good Neutral Poor

Ranking		**Alternative**		
		Downstream of Frobisher SPS		
		5A	5B	5C
Category	**Criteria**	Do Nothing	Twin Sewer	Replace Sewer Section
Technical	Hydraulic Improvements			
	Operations and Maintenance			
	System Resiliency			
Ease of Implementation	Constructability			
	Regulatory Considerations	-	-	-
Social	Impact for Surrounding Residents			
System Suitability	Consistency with Planned Upgrades			
	Consistency with Operating Strategies			
Environment/ Sustainability	Carbon Footprint			
	Impact on Terrestrial/ Aquatic Systems			
Financial	Capital Cost			
	Operating and Maintenance Cost			
Total Score		5	5 3/4	6 3/4

Table 6-13: Results of Evaluation for Alternative 6

Ranking

Good Neutral Poor

Ranking		**Alternative**		
		Lower Forwell Trunk		
		6A	6B	6C
Category	**Criteria**	Do Nothing	Twin Sewer	Replace Sewer Section
Technical	Hydraulic Improvements			
	Operations and Maintenance			
	System Resiliency			
Ease of Implementation	Constructability			
	Regulatory Considerations			
Social	Impact for Surrounding Residents			
System Suitability	Consistency with Planned Upgrades			
	Consistency with Operating Strategies			
Environment/ Sustainability	Carbon Footprint			
	Impact on Terrestrial/ Aquatic Systems			
Financial	Capital Cost			
	Operating and Maintenance Cost			
Total Score		7 1/4	5 1/4	6

6.7 INFLOW AND INFILTRATION

The 2013/2014 flow monitoring program had coverage across the entire City's sanitary network. However, the relocation of various monitors is recommended to further target areas of aging infrastructure with suspected I/I. The proposed flow monitoring locations are identified in Figure 6-6. The proposed locations for flow monitor deployment are listed below:

1. Downtown Core as part of the Optimization and Rehabilitation Program
2. Clair Trunk
3. Cedar Trunk
4. Forwell Trunk

These areas have been selected based on the review of historical data and current data from the 2013/2014 Flow Monitoring Program. Flow monitoring in these areas represent opportunity to understand longer term I/I impacts in addition to new point loads entering the sanitary system.

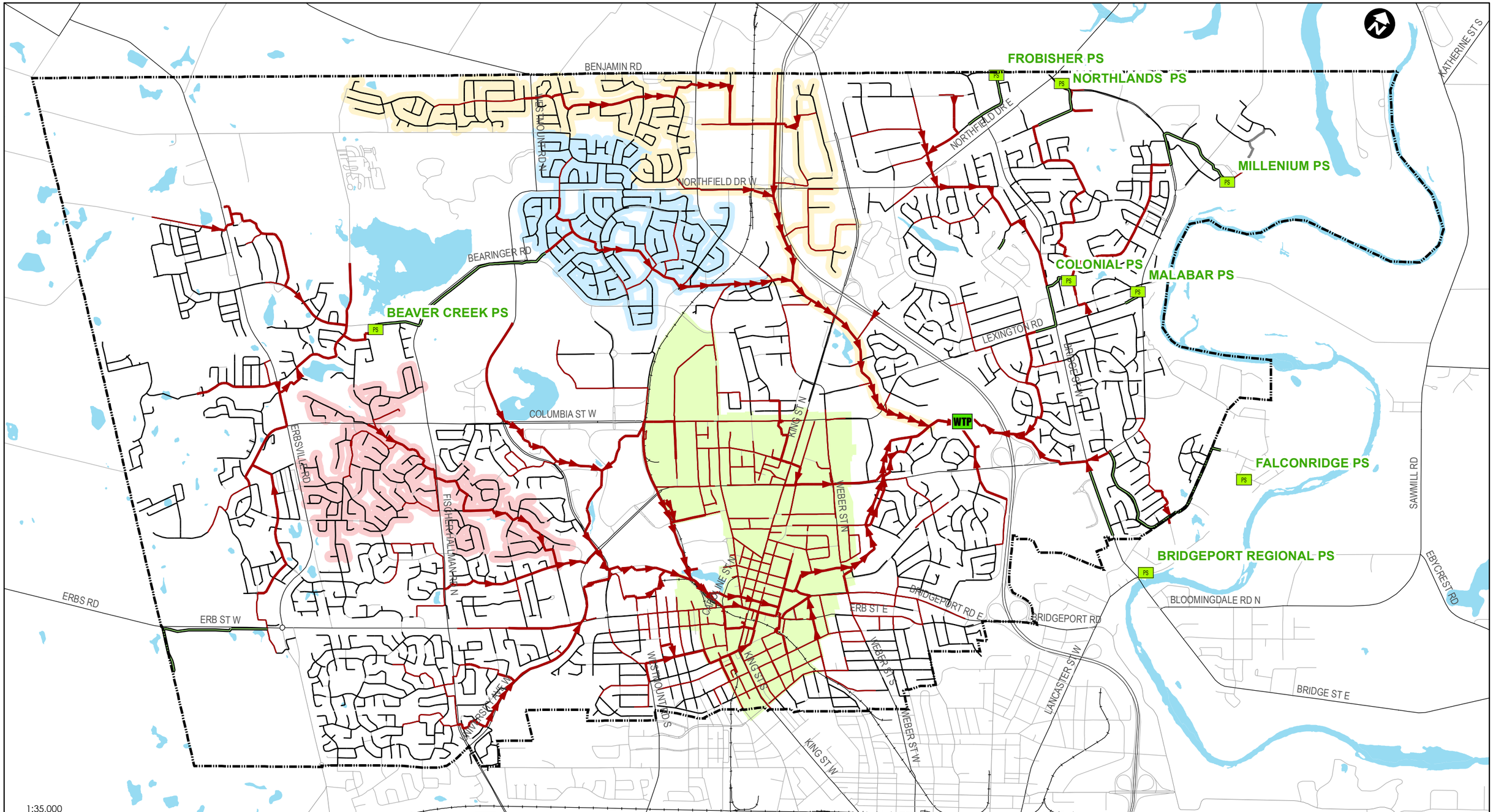
6.8 OPTIMIZATION AND REHABILITATION

Optimization and rehabilitation is recommended to extend the life of existing infrastructure. Optimization and rehabilitation measures are recommended to be focused on the following three (3) priority areas:

1. Priority Area 1 –Core Area overlapping with Station Areas with older infrastructure.
2. Priority Area 2 – Station Areas with older infrastructure.
3. Priority Area 3 – All other areas with older infrastructure.

Within each of the areas, a study phase followed by rehabilitation stage is recommended:

1. Study of Catchment:
    a. Data Validation.
    b. Model Checks.
    c. CCTV (review existing and new, as needed).
    d. Flow monitoring.
    e. Development of rehabilitation strategy/tender.
2. Rehabilitation of Catchment Area.
3. Repeat for catchments within Priority Area and then move on to next priority area.



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Legend

- PS — Existing Pump Station
- Forcemain
- WTP — Wastewater Treatment Plant

All Sanitary Sewers
- Local Sewers
- Trunk Sewers

Model Selection Set
- Local Sewers
- Trunk Sewers

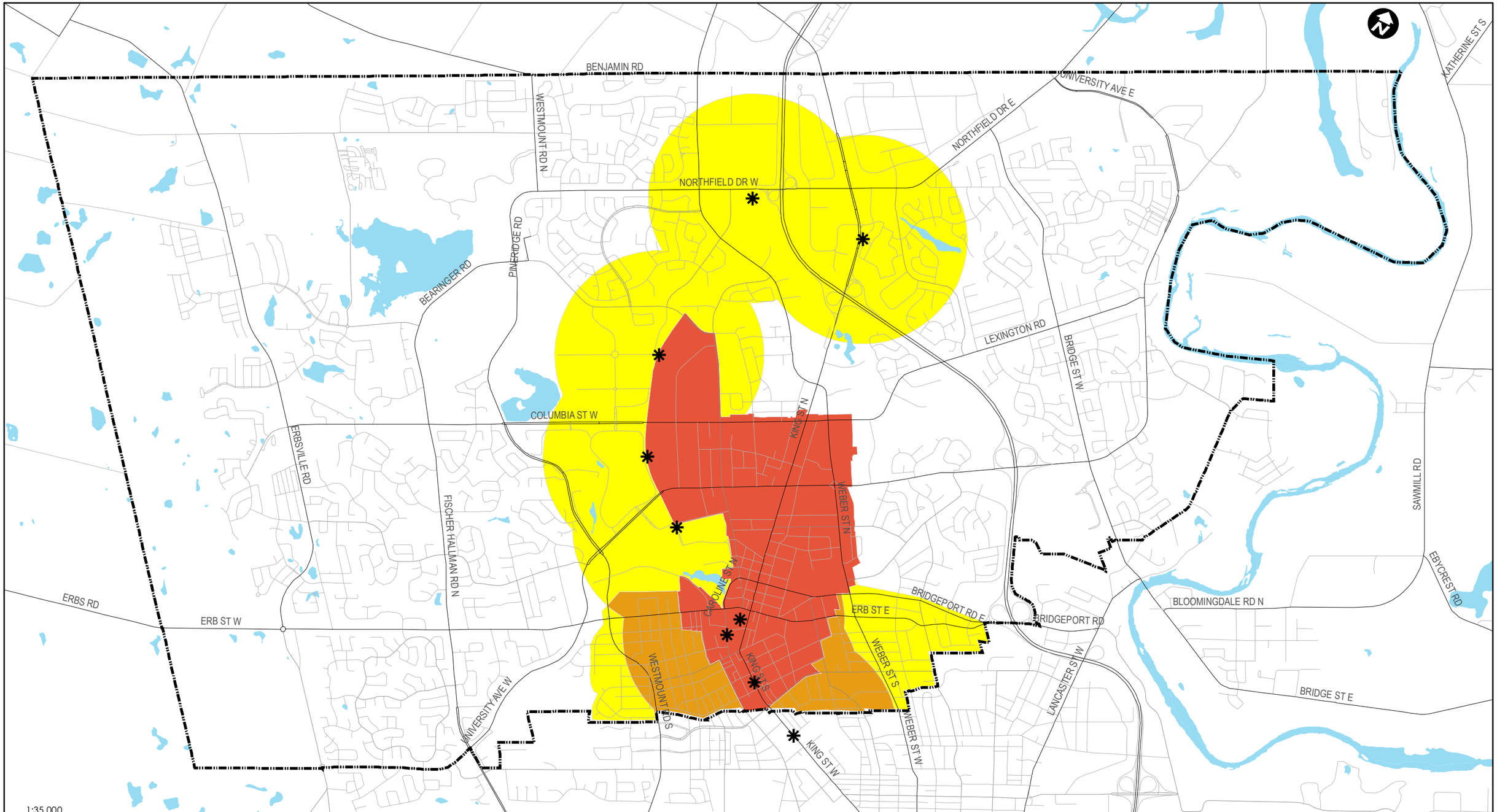
I/I Reduction Target Area
- Downtown Core
- Clair Sewershed
- Cedar Sewershed
- Forwell Sewershed

1611-11191

Figure No. FIGURE 6-6

Title **I/I REDUCTION TARGET AREAS**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE



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Legend

- Rapid Transit Station

Rehabilitation Areas

- Priority 1
- Priority 2
- Priority 3

1611-11191

Figure No. FIGURE 6-7

Title **OPTIMIZATION AND REHABILITATION PROGRAM PRIORITY AREAS**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE

6.9 CORE AREA INFRASTRUCTURE ASSESSMENT

The Core Area Infrastructure Assessment (CAIA), completed in 2011 provided recommendations for sanitary sewer upgrades within the Core Area based on anticipated growth. The status of each sanitary constraints identified in the CAIA has been summarized in Section 2.3.2. Many of the constraints identified have already been addressed through infrastructure upgrades. The outstanding constraints are listed in Table 6-14 below:

Table 6-14: Status of Core Area Infrastructure Assessment Sanitary Recommended Upgrades

Description	2015 Capital Upgrades	CAIA	Comments
Allen Street West	Not included in 2015 Capital Upgrades	Cluster 89 - Priority 1 upgrades required.	Upgrades Not Completed
Union St E	Not included in 2015 Capital Upgrades	Cluster 75 - Priorities 1, 2, and 3 upgrades identified.	Upgrades Not Completed
Willis Way / Regina St S Sanitary Sewer Upsizing	Ref 862 - Cost to be split between Development Charges, GTR, and Sewer Ent.	Cluster 82 - Priority 1 upgrade along Regina at Willis Way, and Priority 2 along Willis Way and King St.	Upgrades Not Completed
Bridgeport Rd E / Laurel St / Easement	Not included in 2015 Capital Upgrades	Cluster 81 – Priority 1 upgrades identified along Bridgeport at Laurel, and along William. Priority 1 upgrades identified along easement at Erb and Laurel.	Upgrades Not Completed

Although these constraints were identified within the CAIA, they have not been identified as constraints within the 2014 Master Planning Process. This discrepancy can be attributed to differences in methodology and data availability between the two studies. Although both studies used hydraulic models to identify constraints, an uncalibrated static model was used in the CAIA, whereas a calibrated dynamic model was used in the 2014 Master Plan. In addition, a significant amount of additional field data was collected and incorporated into the City's geodatabase which eliminated previously-identified constraints.

7.0 RECOMMENDATIONS AND STAGING FOR SANITARY SERVICING STRATEGIES

7.1 REVIEW OF 2015 APPROVED CAPITAL BUDGET

A review of the current 2015 Approved Capital Budget has been completed to identify any opportunities to eliminate or defer projects as a result of the 2014 Master Plan findings. During this review, five (5) projects have been identified which are carried within the 2015 Capital Budget; However the modelling results of the 2014 Master Plan do not indicate capacity constraints within these areas. It is therefore recommended that the following items be removed from the Capital Budget:

- Ezra Avenue Sanitary Sewer Upsizing
- Keats Trunk Sewer Replacement
- Maple Hill Trunk - Westcourt Place Upsizing
- Maple Hill Trunk - Westvale Drive to Thorndale Place
- Willis Way / Regina Street South Sanitary Sewer Upsizing

The removal of these items from the Capital Plan is based on the capacity assessment alone. In the event that upgrades are required for reasons other than capacity (i.e. age of infrastructure, deteriorating condition), then implementation of these upgrades would be recommended.

It should be noted that these items have been previously identified for upgrades; although these items were not identified within the 2014 Master Plan assessment, it is recommended that these areas be monitored to confirm that these sewer upgrades are not required; alternatively, these projects may be included under the Optimization and Rehabilitation Plan. Accordingly, it is recommended to confirm that these upgrades are not required. It is recommended that the City purchase an additional two (2) flow monitors, and monitor these five (5) areas intermittently over a five (5) year period.

7.2 COMPONENTS OF UPDATED MASTER PLAN/CAPITAL PROGRAM

7.2.1 Proposed Priority and Strategic Projects

Recommended sewer infrastructure works are categorized into Priority Projects and Strategic Projects. The Priority Projects are recommended to be completed within the next five (5) year cycle, and Strategic Projects are grouped into five (5) year increments:

- Priority Projects (2016 to 2019)

- Strategic Projects (2020 to 2024)
- Strategic Projects (2025 to 2029)

Priority and Strategic Projects are identified in Figure 7-1 and listed below. Projects that are currently carried in the 2015 Capital Budget are indicated with a star (*). Priority Projects (2016 to 2019) are listed below:

- Beaver Creek SPS Upgrades*1
- Beaver Creek Road Trunk Extension and Construction of SPS #2 and SPS #3*1
- Municipal Servicing to Properties on Private Services (Priority 1)
- Maple Hill Trunk Capacity
- I/I Program – Phase 1
- Optimization and Rehabilitation – Priority 1

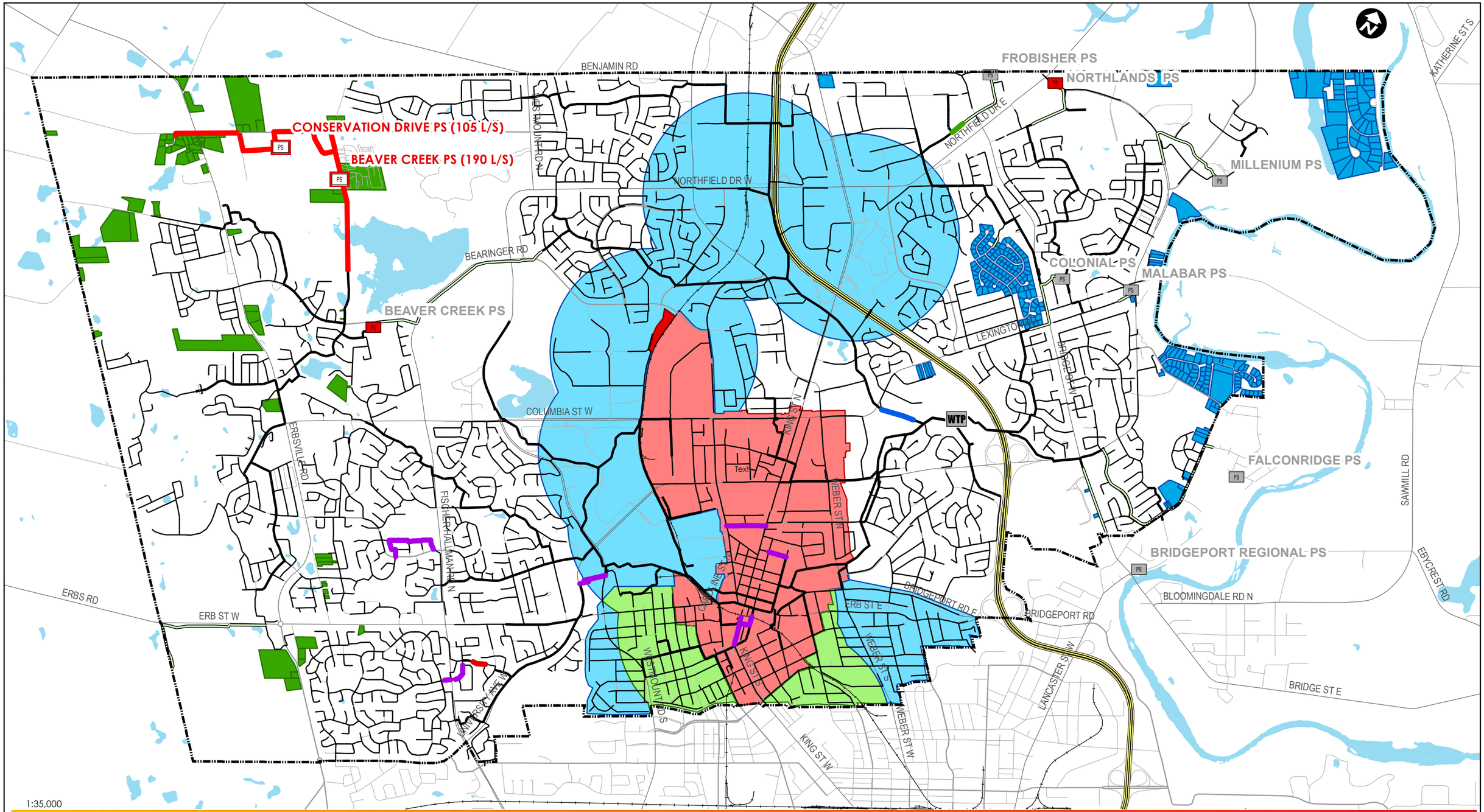
Strategic Projects include (2020 to 2024):

- Frobisher SPS Downstream – Trunk Capacity
- I/I Program – Phase 2
- Optimization and Rehabilitation – Priority 1 and Priority 2

Strategic Projects include (2025 to 2029):

- I/I Program – Phase 3
- Optimization and Rehabilitation – Priority 2 and Priority 3

Note 1: The location of all future City sanitary pumping stations should include adequate buffer zones between any residential land uses.



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Legend

- PS Sewage Pump Station
- Forcemain
- WTP Wastewater Treatment Plant

Sanitary Sewers

- Local Sewer
- Trunk Sewer

Priority Projects (2015 to 2019)

- Linear Upgrade
- Rehabilitation Areas
- Properties on Private Services
- PS Pump Station Upgrades
- PS Proposed Pump Station

Strategic Projects (2020 to 2024)

- Linear Upgrade
- Rehabilitation Areas
- Properties on Private Services

Strategic Projects (2025 to 2029)

- Linear Upgrade
- Rehabilitation Areas
- Properties on Private Services

Projects to be Removed from Capital Budget

Note: Sanitary Servicing in the Beaver Creek Development Area is in Design Phase, Alternate Alignments Have Been Proposed.

1611-11191

Figure No. FIGURE 7-1

Title **PRIORITY AND STRATEGIC PROJECTS**

Client/Project CITY OF WATERLOO SANITARY SERVICING MASTER PLAN UPDATE

7.2.2 Strategies Related to Intensification and Climate Change

Due to anthropogenic climate change, it is generally expected that in most areas of the country, design storm intensities will increase, especially for shorter storm durations (Canadian Standards Association, DRAFT 2010). Further, it is anticipated that events which are now considered extreme will become more frequent in occurrence.

There is a legacy of existing infrastructure built to older design standards based on historical information, an approach that continues to be used to this day due to the technical challenges and inherent uncertainties in developing climate-adjusted IDF curves for future periods. As a result, infrastructure may be subject to loadings which exceed original design capacity. Changing climate may be offset by the effect of other conservative engineering assumptions used at the time of design (e.g. increased per capita rates, increased pipe sizes, etc.). Contrarily, the intensity, duration, and/or frequency of precipitation events may decrease and therefore become less onerous on the system.

Climate change was incorporated into this Master Plan by selecting the 10-yr, 3 hour Chicago storm as the design event. This storm is characterized by its high intensity and short duration; the 10-yr design storm was selected to provide a conservative assessment of the system performance. Additional information on the impacts of climate change on municipal infrastructure can be found in Appendix A.

8.0 OPINION OF PROBABLE COSTS

8.1 REVIEW OF 2015 APPROVED CAPITAL BUDGET

A review of the current 2015 Approved Capital Budget has been completed, as discussed in Section 7.1. Five (5) projects have been identified which are currently carried within the 2015 Capital Budget; however, the modelling results of the 2014 Master Plan do not indicate capacity constraints within these areas. It is therefore recommended that these items, summarized in Table 8-1 be removed from the Capital Budget. A summary of the items to be removed from the Capital Budget, and the budgeted funds for each, are summarized in Table 8-1. Additional Flow monitoring is recommended to confirm that these upgrades are not required. Additional details regarding the recommended flow monitoring plan is discussed in Section 7.1, and a detailed breakdown of the opinion of probable cost is included in Appendix D.

Table 8-1: Projects Removed from Capital Budget

	Project Description	EA and Study Requirements	Priority Projects (2016 to 2019)	Strategic Projects (2020 to 2024)	Strategic Projects (2025 to 2029)
Ref	**Projects Currently Carried in the 2015 Capital Budget**				
857	Ezra Avenue Sanitary Sewer Upsizing	Schedule 'A'	$108,000		
858	Keats Trunk Sewer Upsizing to 250mm	Schedule 'A'	$289,000	$621,000	
859	Maple Hill Trunk - Westcourt Place - Upsizing	Schedule 'A'	$288,000		
860	Maple Hill Trunk - Westvale Dr. to Thorndale Pl.	Schedule 'A'	$827,000		
862	Willis Way / Regina St S Sanitary Sewer Upsizing	Schedule 'A'	$164,000		
Total Costs per Planning Period			**$1,676,000**	**$621,000**	**$0**

8.2 OPINION OF PROBABLE COST

The Master Plan recommendations consist of a series of individual projects which will collectively constitute the preferred Master Plan Servicing Scheme. A list of these projects, grouped into

Priority Projects and Strategic Projects, and the associated opinion of probable cost is summarized in Table 8-2.

The opinion of probable cost supports the recommended servicing scheme for each item. These estimates were prepared based on preliminary sizing of the required system components and consideration for the topography of proposed development areas. The opinion of probable costs for all new capital upgrades, I/I reduction efforts, and rehabilitation and optimization efforts have been based on established unit costs which can be found in the Appendix D. Any additional studies required for I/I reduction efforts and rehabilitation and optimization efforts are to be included in the opinions of probable costs. The opinions of probable costs for all existing projects have been extracted from the City of Waterloo 2015 Approved Capital Budget.

The cost estimates for capital upgrades include the following contingencies and project allowances:

- Capital Cost Contingency (20%)
- Project Delivery Allowance including:
    - Engineering Services (16%)
    - Project Management and Administrative Costs internal to the City (3% for Projects >$1.5M; 5% for Projects <=$1.5M)
    - Project Delivery Contingency (10%)

The cost estimates are to be reviewed and updated for council on a periodic basis. The continual process of review and revision will permit the refinement of the cost estimates through detailed design of specific projects.

Table 8-2: Preliminary Plan for Implementation and Staging

	Project Description	EA and Study Requirements	Priority Projects (2016 to 2019)	Strategic Projects (2020 to 2024)	Strategic Projects (2025 to 2029)
Ref	**Projects Currently Carried in the 2015 Capital Budget**				
690	Northlands Sanitary Pumping Station Upgrade (EA Underway)	Schedule 'B'		$1,924,000	
691	Conservation Drive and Beaver Creek Road Lands Surrounding SPS# 2 and SPS #3	Schedule 'B'	$1,097,000		
692	Cedar Trunk 1 - Erb Street to approx. 720 m. south of Erb Street	Schedule 'B'	$289,000		
693	Conservation Drive - From SPS #2 to Beaver Creek Rd	Schedule 'B'	$108,000		
694	SPS #2 on Conservation Dr @ Beaver Crk Road	Schedule 'B'	$1,604,000		
850	Beaver Creek Pumping Station Emergency Storage Tank	Schedule 'D'	$1,318,000		
851	Water Services Quality Management System	N/A	$209,000		
852	City Wide - Sanitary Access Roads / Paths	N/A	$621,000	$457,000	
853	Sanitary Sewer Lateral Camera Inspections in conjunction with Roads	N/A	$412,000	$455,000	
854	Blackpipes Rehabilitation - Proactive	N/A	$1,526,000	$1,713,000	
855	City Wide - Development Driven Sanitary Sewer Upgrades	N/A	$1,054,000	$611,000	
856	Defective Sewer Main Spot Repairs/Rehabilitation	N/A	$584,000	$645,000	
861	Sanitary Sewer Master Plan - Implementation	N/A	$1,480,000		

	Project Description	EA and Study Requirements	Priority Projects (2016 to 2019)	Strategic Projects (2020 to 2024)	Strategic Projects (2025 to 2029)
Ref	**Projects Currently Carried in the 2015 Capital Budget**				
Ref	**2014 MP Update Projects**				
	Municipal Servicing – Priority 1	Various	$132,000		
	Municipal Servicing – Priority 2	Various		$2,805,000	
	Municipal Servicing – Priority 3	Various			$9,644,000
	Maple Hill Trunk Capacity	Schedule 'A'	$36,000		
	Frobisher SPS Downstream – Trunk Capacity	Schedule 'A'		$164,000	
	Lower Forwell Trunk Capacity	Schedule 'A'			Do Nothing
	I/I Program	N/A	$194,000	$160,000	$160,000
	Optimization and Rehabilitation – Priority 1	N/A	$1,641,000	$547,000	
	Optimization and Rehabilitation – Priority 2	N/A		$467,000	$467,000
	Optimization and Rehabilitation – Priority 3	N/A		$678,000	$1,376,000
	Monitoring of Projects Removed from Capital Budget	N/A	$29,000		
Total Costs per Planning Period			**$12,334,000**	**$10,626,000**	**$11,647,000**

9.0 REFERENCES

Development, interpretation and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners (Canadian Standards Association, DRAFT 2010)